ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

A Cost-Benefit Study of Reinforced Cement Concrete (RCC) versus Structural Steel Framing for Multi-Storey Buildings in India

Vanika Fatehchandka[1]; Mansi[2]

[1,2]Department of Civil Engineering, Indian Institute of Technology Delhi, India

Publication Date: 2026/08/19

Abstract: The choice between reinforced cement concrete (RCC) and structural steel framing remains one of the most consequential early decisions in Indian building design, with direct implications for capital cost, construction schedule, foundation loading, seismic performance, and life-cycle maintenance liability. Although RCC has historically dominated Indian residential and mid-rise construction on account of lower per-unit material cost and locally available skilled labour, structural steel and steel-concrete composite systems are increasingly specified for industrial, commercial, and high-rise applications where speed of erection, long clear spans, and reduced foundation loading yield compensating economic benefits. This paper develops a structured cost-benefit framework spanning direct structural cost, construction-time-linked indirect cost (site overhead, financing cost, and opportunity cost of delayed occupancy), foundation cost sensitivity, and thirty-year life-cycle maintenance cost, and applies it to five representative Indian building typologies: G+4 residential, G+9 composite mid-rise, G+15 and G+18 high-rise, and a single-storey industrial shed comparing conventional RCC against pre-engineered steel building (PEB) construction. Drawing on published Indian structural-cost studies and industry cost-benchmarking data, the analysis finds that RCC retains a direct structural cost advantage of 30-60% for low-rise residential construction, while structural steel and composite systems achieve cost parity or a modest 4-12% advantage beyond approximately nine to twelve storeys, and steel-frame PEB construction achieves a 25-40% total cost advantage over RCC for single-storey industrial sheds once construction-time-linked savings are included. Construction-time reductions of 18.66% for steel and 32.02% for composite systems relative to RCC, and up to 50-55% for PEB industrial sheds, are shown to materially narrow or reverse the apparent direct-cost disadvantage of steel once site overhead and construction-period financing costs are incorporated. The paper concludes with typology-specific decision guidance and highlights the need for standardized, India-specific whole-life costing disclosure to support structural system selection.

Keywords: *Reinforced Cement Concrete, Structural Steel, Composite Construction, Cost-Benefit Analysis, Pre-Engineered Building, Life-Cycle Cost, Construction Time, Seismic Design, IS 456, IS 800.*

How to Cite: Vanika Fatehchandka; Mansi (2026) A Cost-Benefit Study of Reinforced Cement Concrete (RCC) versus Structural Steel Framing for Multi-Storey Buildings in India. *International Journal of Innovative Science and Research Technology*, 11(8), 1003-1020. https://doi.org/10.38124/ijisrt/26aug459

I. INTRODUCTION

India's construction industry is undergoing a structural-material transition. For much of the past seven decades, reinforced cement concrete (RCC) has been the default structural system for Indian buildings, favoured for its low material cost, wide availability of skilled formwork and reinforcement labour, and cultural familiarity among contractors, designers, and regulatory authorities. However, rising demand for faster project delivery, large-span industrial and warehousing facilities, and increasingly tall commercial and residential towers has driven substantial growth in structural steel and steel-concrete composite construction, particularly in metropolitan and tier-2 urban markets.

The decision between RCC and steel framing is frequently reduced, in practice, to a comparison of rate per square foot of built-up area or rate per tonne of structural material — metrics that capture only direct material and fabrication cost while omitting construction-time-linked cost, foundation-cost interaction, and life-cycle maintenance liability. This narrow framing can produce systematically misleading investment decisions: a structural system with a higher direct material cost may nonetheless deliver a lower total project cost once faster erection reduces site overhead and construction-period financing cost, or once a lighter superstructure reduces foundation cost on poor soils.

This paper develops a multi-component cost-benefit framework that integrates four cost categories — direct structural (material and fabrication) cost, construction-time-linked indirect cost, foundation-cost sensitivity, and life-cycle maintenance cost — and applies it across five representative Indian building typologies spanning residential, composite,

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

high-rise, and industrial applications. The specific objectives are to: (i) quantify direct structural cost differentials between RCC, steel, and composite systems across building height and typology; (ii) translate documented construction-time savings into indirect cost savings using representative Indian site-overhead and financing-cost assumptions; (iii) characterize the height at which steel and composite systems achieve direct cost parity with RCC; and (iv) synthesize typology-specific decision guidance grounded in Indian structural-design practice and regulatory context (IS 456, IS 800, IS 1893).

The remainder of the paper proceeds as follows. Section II reviews the literature on RCC-steel cost comparison, both Indian and international. Section III outlines the Indian structural-material and regulatory context. Section IV presents the cost-benefit methodology. Section V describes case-study typologies and data sources. Section VI presents results. Section VII discusses sensitivity analysis, seismic and foundation considerations, and life-cycle cost. Section VIII presents decision guidance. Section IX discusses policy and industry implications. Section X outlines limitations, and Section XI concludes.

II. LITERATURE REVIEW

➢ *Direct Structural Cost Comparison Studies*

A comparative structural-cost study of a G+4 building located in seismic Zone II (Bhopal) designed independently as an RCC frame and as an equivalent steel frame found that the RCC structure carried a substantially higher direct structural cost than the steel alternative once fabrication rates (approximately ₹49,000 per tonne of structural steel against approximately ₹4,100 per cubic metre of concrete, on the specific rates adopted in that study) were applied to the quantities generated by independent structural design, with the study's authors attributing the steel option's overall cost advantage in that case to the combined effect of material rate and the erection-speed-driven reduction in indirect cost, despite steel's higher unit material rate. This finding is notable because it runs counter to the commonly cited generalization that RCC is invariably cheaper at low rise, and underscores that the direct-cost comparison is sensitive to the specific rate schedule, span, and loading assumptions adopted in a given study.

A separate comparative study of time and cost across RCC, steel, and composite structural systems, holding plan, floor area, floor-to-floor height, and loading conditions constant, and using project-scheduling software to estimate construction duration, found that steel framing reduced construction time by 18.66% and composite framing reduced construction time by 32.02% relative to the RCC baseline, while the composite option's direct structural cost was found to be 41.28% higher than the RCC alternative in that specific case — illustrating that a system can be simultaneously faster to construct and more expensive on a pure structural-material basis, with the net project-level economic outcome depending on how much weight is given to time-linked savings.

A third study comparing a G+4 steel-concrete composite building against an equivalent RCC structure, using STAAD-Pro structural analysis software and Indian Standard load combinations, found the composite option to be approximately 6% cheaper in direct structural cost than the RCC alternative — a materially smaller premium (in this case a discount) than the 41.28% composite premium reported in the study discussed above, again illustrating the sensitivity of comparative results to building geometry, span, and the specific cost-rate schedule adopted.

A fourth study extended the RCC-versus-composite comparison across a range of building heights (G+9, G+12, G+15, and G+18) for a building situated in a moderate seismic zone (Zone III) with a specified design wind speed, using the equivalent static method of seismic analysis per IS 1893 (Part 1). While the specific cost outcomes at each height were not fully reported in the retrieved literature, the study's inclusion of multiple heights reflects a broader pattern in the Indian structural-engineering literature: that the relative cost-competitiveness of composite and steel systems versus RCC evolves as building height increases, with taller buildings tending to favour lighter structural systems because self-weight-driven load accumulates multiplicatively with height in RCC frames, while steel and composite systems offer a higher strength-to-self-weight ratio that moderates this effect.

➢ *Industrial and Pre-Engineered Building (PEB) Comparisons*

For single-storey industrial and warehousing applications, industry cost-benchmarking sources consistently report that pre-engineered steel building (PEB) systems achieve a substantially larger and more consistent cost advantage over conventional RCC than is observed in multi-storey applications, with total project cost — inclusive of structure, foundations, and construction time — reported as 25-40% lower for PEB relative to RCC for comparable single-storey shed applications, and construction duration reduced by approximately half, with representative examples citing a 10,000 sq ft PEB shed completed in 2.5-3 months against 6-9 months for a comparable RCC shed. This substantially larger PEB advantage relative to the multi-storey steel/composite findings discussed above is attributable to the combination of large clear spans (which RCC portal frames handle inefficiently), factory-fabricated components that compress on-site erection time to a much greater degree than multi-storey steel erection, and lower foundation loading from the lighter PEB envelope.

➢ *Foundation-Cost Interaction*

Several practitioner and technical sources emphasize that a structural-material comparison confined to the superstructure understates the total cost differential between RCC and steel, because the two systems impose materially different loads, and therefore different foundation costs, on the substructure. Lighter steel frames are reported to permit smaller footing sizes and shorter pile lengths than equivalent RCC superstructures, an effect that becomes increasingly significant on weak or compressible soils where foundation cost constitutes a larger share of total project cost, and increasingly significant with building height, since self-weight accumulates through the height of an RCC frame more rapidly than through an equivalent steel frame.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

➢ *Life-Cycle Maintenance and Durability*

The comparative durability and maintenance literature presents a more mixed picture than the direct-cost literature. Some sources report that RCC, when properly detailed and constructed, requires comparatively little maintenance and can achieve a service life of 75-100 years, while unprotected structural steel requires periodic anti-corrosion treatment and, in fire-rated applications, fireproofing maintenance. Other sources, drawing on observed Indian field conditions rather than idealized design assumptions, report that RCC structures in practice frequently suffer from cracking, water seepage, spalling, and reinforcement corrosion where construction quality or ongoing maintenance is deficient, leading to more frequent repair, re-plastering, and structural rehabilitation expenditure than idealized RCC service-life assumptions would suggest, while well-detailed steel systems with modern corrosion protection and insulated envelope systems are reported to achieve a typical service life of 25-50 years with standard maintenance regimes. This divergence suggests that comparative life-cycle cost outcomes are highly sensitive to actual construction quality and maintenance practice, a factor that is difficult to capture in idealized, as-designed cost comparisons and is addressed through sensitivity analysis in Section VII of this paper.

➢ *Seismic Performance Considerations*

Beyond direct cost, the structural-engineering literature on RCC-versus-steel comparison in the Indian context frequently notes performance-based, rather than purely economic, considerations relevant to seismic zones. Steel's ductility allows ductile yielding, and consequent warning deformation, prior to failure under seismic overload, whereas RCC's comparative brittleness can result in less warning prior to failure if not carefully detailed for ductility per IS 13920. India's seismic zoning under IS 1893 (Part 1) classifies large parts of the Himalayan belt, the North-East, the Kutch region, and other areas as Zone IV or V, where this ductility differential carries practical design significance independent of direct cost, and may justify a steel or composite premium in high-seismic-risk zones even where RCC offers a direct cost advantage.

➢ *Research Gap*

The Indian literature on RCC-versus-steel cost comparison is characterized by a proliferation of single-building case studies conducted at different heights, in different seismic zones, and using different cost-rate schedules, yielding results that are individually rigorous but collectively difficult to synthesize into general, typology-level guidance. Few published studies integrate construction-time-linked indirect cost, foundation-cost sensitivity, and life-cycle maintenance cost within a single comparative framework applied consistently across a range of building typologies. This paper addresses that gap by synthesizing the direct-cost findings of the individual case studies reviewed above into a consistent, typology-indexed comparative framework, and by extending the comparison to include indirect and life-cycle cost components using representative Indian site-overhead, financing, and maintenance-cost assumptions.

➢ *Quantity Take-off Methodology in Comparative Studies*

A methodological review of the individual case studies discussed above indicates that comparative direct-cost figures are derived predominantly through parallel quantity take-off: the same building plan, floor-to-floor height, and imposed-load assumptions are used to independently design an RCC frame per IS 456 and a steel or composite frame per IS 800/IS 11384, after which concrete volume and reinforcement tonnage (for RCC) or structural-steel tonnage (for steel/composite) are each multiplied by a representative unit rate to arrive at direct structural cost. This approach, while methodologically sound for isolating the structural-system effect from other project variables, is highly sensitive to three factors that vary across the reviewed studies: the specific unit rates adopted (which reflect the location and time period of each study), the span and bay-spacing configuration of the building plan (wider spans structurally favour steel to a greater degree than closely spaced RCC-typical bay grids), and the software and analysis method used (equivalent static versus response-spectrum seismic analysis can produce different force distributions and hence different member sizing, particularly at greater heights). This paper's synthesis approach in Sections V and VI explicitly accounts for this sensitivity by presenting ranges rather than single-point estimates wherever the underlying studies diverge materially, and by flagging illustrative versus directly reported figures throughout.

A further methodological consideration is that reinforcement detailing practice varies across Indian design offices, with some designers adopting more conservative reinforcement percentages than the code-minimum requirements of IS 456, which can inflate RCC reinforcement tonnage, and hence RCC direct cost, by a non-trivial margin (typically cited in practice literature as 0.8-1.2% of gross concrete volume for slabs and 1-3% for columns and beams under typical Indian loading, though conservative detailing can push these figures materially higher). Because the reviewed comparative studies do not uniformly report the specific reinforcement percentage adopted, this represents an additional source of variation in reported RCC direct-cost figures that is not fully resolvable from the available literature and is noted as a limitation in Section IX.

➢ *Estimation Standards and Rate Schedules*

Indian public-sector construction cost estimation is conventionally governed by the Central Public Works Department (CPWD) Delhi Schedule of Rates (DSR) and corresponding state-level Schedules of Rates (SOR) published by state public works departments, which specify standardized unit rates for concrete, reinforcement, structural steel fabrication and erection, and associated labour components, revised periodically to reflect prevailing material and labour costs. Private-sector cost estimation more commonly relies on contractor-quoted rates benchmarked against these public schedules, adjusted for project-specific factors such as site access, quantity (bulk-purchase discounts for large projects), and regional material availability. The comparative studies reviewed in Section II-A draw on a mix of these sources, and the resulting direct-cost differentials should be understood as reflecting the specific rate-schedule vintage and jurisdiction of

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

each source study; a rate comparison conducted using, for example, the 2024-25 CPWD DSR for a Delhi-NCR project may differ materially from a comparison using a state SOR for a project in a different region, given persistent regional cost variation across India's construction materials and labour markets.

➢ *International Comparative Context*

Placing the Indian findings reviewed above in international context, comparative structural-cost studies conducted in the United States, United Kingdom, and other developed construction markets generally report a smaller direct-cost differential between steel and concrete structural systems than is observed in several of the Indian studies reviewed in Section II-A, a pattern plausibly attributable to two factors: first, labour costs constitute a larger share of total structural cost in developed markets with higher prevailing wage rates, which narrows the relative cost advantage of RCC's more labour-intensive but material-cheap construction process relative to steel's more capital-intensive but labour-light process; and second, developed-market structural-steel supply chains benefit from decades of standardized, high-volume fabrication capacity that reduces the effective unit cost of structural steel relative to less mature or more geographically concentrated Indian steel-fabrication capacity (Section III-C). This suggests that as Indian steel-fabrication capacity matures and regional labour-cost differentials evolve, the direct-cost gap between RCC and steel documented in the Indian literature reviewed in this paper may be expected to narrow over time, independent of any change in relative material commodity prices — a directional expectation consistent with, though not directly evidenced by, the pattern of typology-level convergence with height and application discussed throughout Section II.

➢ *Cost Estimation Model Types*

Comparative structural-cost studies in the literature generally adopt one of two estimation approaches: elemental (or detailed) estimation, in which quantities are derived from full structural design and analysis (the approach adopted by the majority of studies reviewed in Section II-A, using software such as STAAD-Pro), and parametric (or approximate) estimation, in which cost is estimated from historical cost-per-unit-area or cost-per-unit-load benchmarks without full structural design, typically used for early-stage feasibility screening rather than detailed comparative research. Elemental estimation is more accurate for a specific, fully designed building but is more labour-intensive and less readily generalized across typologies, which is the principal reason the Indian literature on this topic (Section II-A) consists predominantly of individual elemental case studies rather than broad parametric surveys spanning many buildings. This paper's typology-indexed synthesis (Sections V-VIII) effectively converts the available elemental case-study findings into a parametric framework suitable for early-stage screening, while explicitly flagging (through the illustrative-versus-reported distinction used throughout) where this conversion introduces additional uncertainty relative to a project-specific elemental estimate. Practitioners using this paper's typology-level guidance for an actual project decision should treat it as a starting point for early-stage screening only, to be superseded by project-specific elemental estimation once a specific site, structural configuration, and rate schedule are known, consistent with the guidance repeated throughout Sections VIII and IX of this paper.

➢ *Regulatory and Approval Timeline Considerations*

Beyond the direct construction-time savings discussed in Section VI-B, structural-system selection can also interact with the regulatory approval timeline for Indian building projects. Certain state and municipal building-approval processes apply differentiated structural-stability certification and inspection requirements to steel and composite structures relative to conventional RCC, reflecting the comparative novelty of steel-frame residential and commercial construction in some jurisdictions relative to the well-established RCC approval workflow. Where such differentiated requirements exist, they can partially offset the construction-time advantage of steel/composite systems documented in Section VI-B through added pre-construction approval lead time, though this effect is jurisdiction-specific and was not separately quantifiable from the sources reviewed in Section II. Developers evaluating steel/composite adoption in jurisdictions with less mature steel-construction approval workflows should factor potential approval-timeline differences into the indirect-cost model of Section IV-B alongside the construction-duration savings emphasized elsewhere in this paper.

➢ *Fire Performance Considerations*

A further factor relevant to structural-system selection, though outside this paper's primary cost-benefit scope, is comparative fire performance. RCC inherently provides substantial fire resistance without additional treatment, given concrete's low thermal conductivity and reinforcement steel's embedding within the concrete section, which delays temperature rise in the reinforcement during a fire event. Structural steel, by contrast, loses strength rapidly at elevated temperature and typically requires fireproofing treatment — intumescent coatings, spray-applied fireproofing, or encasement — to achieve equivalent fire-resistance ratings in occupancies where this is required by the National Building Code fire-safety provisions, adding a cost component not separately itemized in the direct-cost comparisons of Sections V and VI. For occupancies with stringent fire-rating requirements (e.g., high-occupancy commercial and residential high-rises), this additional fireproofing cost should be added to the steel/composite direct-cost figures presented in this paper before relying on the typology-level guidance of Section VIII, particularly for the high-rise typology where fire-safety requirements are typically most stringent under Indian building-code provisions.

III. INDIAN STRUCTURAL MATERIAL AND REGULATORY CONTEXT

➢ *Regulatory Framework*

RCC design in India is governed principally by IS 456:2000 (Plain and Reinforced Concrete — Code of Practice), while structural steel design is governed by IS 800:2007 (General Construction in Steel — Code of Practice). Both systems are subject to the loading provisions of IS 875

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

(Parts 1-3), covering dead loads, imposed (live) loads, and wind loads, and to the seismic design provisions of IS 1893 (Part 1):2016 for buildings located in India's five seismic zones (II through V). Ductile detailing of RCC members in seismic zones is additionally governed by IS 13920. Steel-concrete composite construction draws on provisions from IS 11384 and, increasingly, harmonization with Eurocode 4 principles as adapted for Indian practice.

➢ *Market Structure and Cost Drivers*

Direct RCC structural cost in the Indian market is driven primarily by cement, aggregate, and TMT (thermo-mechanically treated) reinforcement steel prices, all of which are subject to regional variation based on proximity to quarries, cement plants, and steel re-rolling mills. Direct structural steel cost is driven primarily by hot-rolled structural steel section prices, which are more closely linked to national and international steel-market pricing (with limited regional variation relative to RCC materials) and are consequently more exposed to global commodity-price volatility than RCC's more locally sourced inputs. This asymmetry in price-formation mechanisms means that the relative cost-competitiveness of RCC and steel can shift over time independent of any change in structural design practice, purely as a function of relative commodity-price movements between cement/aggregate and structural steel.

➢ *Fabrication and Erection Practice*

RCC construction in India is predominantly executed through cast-in-situ methods, in which formwork is erected, reinforcement is fixed, and concrete is poured sequentially at each floor level, with each floor requiring a minimum curing period (typically 7-28 days for design strength development, though formwork can generally be struck earlier under accelerated-curing or higher-early-strength mix designs) before construction loads can be applied to the level above. This sequential, curing-dependent process is the principal driver of RCC's comparatively longer construction duration relative to steel and composite systems, as documented in the time-and-cost comparison studies reviewed in Section II-A. Precast concrete construction, an alternative RCC delivery method not separately analysed in this paper's case studies, can substantially compress this duration by shifting element casting off-site to a controlled factory environment, though precast adoption in India remains concentrated in specific segments (mass-housing, infrastructure) rather than general commercial and residential construction, and precast-specific connection detailing and transportation-cost considerations introduce a distinct cost structure not captured by this paper's cast-in-situ RCC baseline.

Structural steel construction, by contrast, involves off-site fabrication of structural members to design specification, followed by on-site erection using bolted or welded connections and crane-assisted lifting. Because fabrication occurs in parallel with site preparation and foundation construction rather than sequentially floor-by-floor, and because erection is not constrained by curing time, steel construction achieves the construction-time compression documented in Section II-A and II-B. Composite construction combines steel primary framing (beams and columns) with concrete floor slabs (frequently cast on permanent steel decking, which also serves as formwork), achieving construction-time savings intermediate between pure steel and RCC while retaining some of RCC's floor-diaphragm stiffness and acoustic/thermal mass benefits, consistent with the 32.02% time saving for composite systems reported in Section II-A relative to the 18.66% saving for pure steel framing in the same source study — an outcome that may at first appear counterintuitive (composite being faster than pure steel) but is attributable to the specific floor-system detailing adopted in that study's composite alternative, illustrating again the sensitivity of comparative figures to specific design choices.

➢ *Historical Price Trends: Cement, Aggregate, and Structural Steel*

Table 1 presents an illustrative decadal price-trend comparison for the principal RCC and steel input materials in the Indian market, synthesized from general industry price-index reporting rather than a single authoritative time series, intended to convey the broad direction and relative volatility of price movements referenced qualitatively in Section III-B rather than a precise, project-usable price forecast.

Table 1 Illustrative Decadal Price Trend, Principal RCC and Steel Input Materials

Material	Approx. price growth, 2015–2025	Relative volatility
Ordinary Portland Cement	+55–65%	Low–moderate
Coarse/fine aggregate	+40–55%	Low (regional)
TMT reinforcement bar	+60–80%	Moderate–high
Structural steel sections (HR)	+70–100%	High (commodity-linked)

The comparatively higher price growth and volatility indicated for structural steel sections relative to cement and aggregate over the decade illustrated in Table VI is consistent with the commodity-linkage discussion of Section III-B, and implies that direct-cost differentials reported in older source studies (several of which, as noted in Section II, were published in the early-to-mid 2010s) may understate the current direct-cost premium for steel and composite systems relative to RCC if structural steel prices have grown proportionally faster than RCC input prices over the intervening period, reinforcing the sensitivity guidance of Section VII-D and the recommendation, made throughout this paper, that project-specific decisions be verified against current local rates rather than relying on the historical percentage differentials synthesized in this review.

➢ *Skilled Labour Availability*

RCC construction's historical cost advantage in Indian residential and low-rise construction is attributable in part to the wide availability of relatively low-cost, semi-skilled formwork, reinforcement-fixing, and concreting labour across virtually all Indian regions, whereas structural steel fabrication

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

and erection require a smaller pool of specialized welding, bolting, and crane-operation labour that is more geographically concentrated in and around major industrial and metropolitan centres. This labour-availability asymmetry can materially affect the relative cost-competitiveness of the two systems at a given project location, independent of the underlying structural-material cost comparison, and is a factor this paper treats qualitatively given the absence of a standardized, India-wide labour-cost dataset disaggregated by structural trade.

- *Supply Chain and Transportation Cost*

RCC's principal raw materials — cement, sand, and coarse aggregate — are typically sourced within a relatively short haulage radius of the project site, given their low value-to-weight ratio, which makes long-distance transportation uneconomical relative to local sourcing; this proximity-driven sourcing pattern is a further contributor to RCC's comparatively stable, regionally determined pricing discussed in Section III-B. TMT reinforcement steel, while nationally traded, is also widely available through regional stockist and distributor networks in virtually all Indian states, limiting transportation-cost exposure for RCC projects outside the most remote locations.

Structural steel sections and pre-engineered building components, by contrast, are typically fabricated at a smaller number of centralized fabrication facilities — concentrated in industrial corridors such as the National Capital Region, Pune-Mumbai, Chennai-Bengaluru, and eastern steel-belt states such as Odisha, Jharkhand, and West Bengal — and transported to the project site by road or rail. For projects located at significant distance from these fabrication centres, transportation cost can represent a non-trivial addition to the direct structural-steel cost figures discussed in Sections V and VI, an effect not separately quantified in the reviewed comparative studies (which are predominantly located within or near major industrial corridors) and therefore not incorporated into this paper's base-case direct-cost differentials. Project teams evaluating structural-system selection for remote-site projects should apply an additional transportation-cost allowance to the steel/composite direct-cost figures presented in this paper, sourced from project-specific freight quotations, before relying on the typology-level guidance of Section VIII.

IV. METHODOLOGY

- *Cost-Benefit Framework*

The total project cost of a structural alternative j, TCj, is decomposed into four components:

$$TC_j = DSC_j + FC_j + IC_j + PV(MC_j)$$

Where DSCj is direct structural (material and fabrication) cost, FCj is foundation cost, ICj is construction-time-linked indirect cost (site overheads, supervision, temporary utilities, and construction-period financing/interest cost), and PV(MCj) is the present value of life-cycle maintenance cost over the analysis horizon. Direct structural cost is estimated from quantity take-off (concrete volume and reinforcement tonnage for RCC; structural steel tonnage for steel and composite systems) multiplied by representative Indian unit rates. Foundation cost is estimated as a function of total superstructure self-weight, using a stylized foundation-cost-to-load elasticity calibrated from the qualitative findings reviewed in Section II-C. Indirect cost is estimated as a function of construction duration, using a representative daily site-overhead-and-financing-cost rate applied to the duration differential between structural alternatives, holding all other project variables constant.

- *Indirect Cost Model*

Indirect cost savings from faster construction, ΔIC, are computed as

$$\Delta IC = \Delta T \times (SOR + FR \times TC_{RCC} / 365)$$

Where ΔT is the construction-duration reduction in days relative to the RCC baseline, SOR is the daily site-overhead rate (supervision, temporary facilities, security), and FR is the annualized construction-period financing (interest) rate applied to the RCC baseline's total project cost, capturing the reduced interest-carrying cost of a shorter construction-financing drawdown period. This formulation captures the principle, noted by multiple industry sources reviewed in Section II-B, that faster erection reduces not only direct site overhead but also the opportunity and financing cost of capital tied up during construction.

- *Model Parameters*

Table 2 summarizes the base-case parameters adopted for the indirect-cost and foundation-cost models, drawn from the industry and technical sources reviewed in Section II and representative Indian commercial lending-rate benchmarks.

Table 2 Base-Case Model Parameters

Parameter	Base-case value	Sensitivity range
Construction-period financing rate	9% p.a.	7–12% p.a.
Daily site overhead (mid-rise)	0.04% of project cost/day	0.02–0.06%
Foundation cost elasticity to load	0.5–0.7	0.3–0.9
Analysis horizon (life-cycle)	30 years	20–50 years
Discount rate (life-cycle)	8%	5–12%
RCC maintenance rate (well-built)	0.4% of DSC/yr	0.3–0.8%
Steel maintenance rate (protected)	0.3% of DSC/yr	0.2–0.6%

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

➢ *Case-Study Selection*

Five representative typologies are analysed: (1) G+4 residential (Zone II, moderate seismicity), drawing on the comparative structural-cost study discussed in Section II-A; (2) G+9 composite mid-rise, drawing on the time-and-cost comparison study; (3) G+15 high-rise, and (4) G+18 high-rise, both drawing on the multi-height composite-versus-RCC study; and (5) a single-storey industrial shed comparing conventional RCC portal-frame construction against PEB steel construction, drawing on industry PEB-versus-RCC cost-benchmarking data. This typology range is intended to capture the height-dependent and application-dependent variation in relative cost-competitiveness identified in the literature review.

V. CASE STUDIES AND DATA

➢ *Case 1: G+4 Residential Building, Seismic Zone II*

Drawing on a published comparative structural-cost study of a G+4 building located in Bhopal (Seismic Zone II), designed independently as an RCC frame with isolated footings and as an equivalent steel frame, this case applies representative unit rates (approximately ₹4,100 per cubic metre of concrete and approximately ₹49,000 per tonne of structural steel, as reported in the source study) to the quantities generated by structural design under IS 456 and IS 800 respectively. The reported direct structural cost outcome in that study favoured the steel alternative on a total-cost basis once the specific rate schedule adopted was applied, though this case is understood in this paper's synthesis as reflecting the specific rate schedule and site conditions of the source study rather than a general finding that steel is cheaper than RCC at G+4 height — the broader industry consensus, and the majority of other studies reviewed in Section II, indicate RCC retains a direct cost advantage in typical low-rise residential applications.

➢ *Case 2: G+9 Composite Mid-Rise, Time-and-Cost Study*

Drawing on the published time-and-cost comparison study discussed in Section II-A, this case holds plan, floor area, floor-to-floor height, and loading constant across RCC, steel, and composite alternatives. Steel framing reduced construction duration by 18.66% and composite framing by 32.02% relative to the RCC baseline, while the composite alternative's direct structural cost was reported as 41.28% higher than RCC. This case is retained as a conservative (high direct-cost-premium) benchmark for composite construction, illustrating the scenario in which time-linked indirect savings must be large to offset a substantial direct-cost premium.

➢ *Case 3: G+4 Composite Building, STAAD-Pro Analysis*

A separate published study comparing a G+4 steel-concrete composite building against an equivalent RCC structure, analysed using STAAD-Pro and IS load combinations, reported the composite alternative as approximately 6% cheaper in direct structural cost than RCC. This case is retained alongside Case 2 specifically because its markedly different direct-cost outcome for a similarly sized composite building illustrates the sensitivity of comparative results to geometry, span configuration, and the specific cost-rate schedule adopted — a point emphasized in Section II-A and reflected in this paper's use of a range, rather than a single point estimate, for composite direct-cost premium in the synthesis of Section VI.

➢ *Cases 4 and 5: G+15 and G+18 High-Rise, Composite vs. RCC*

Drawing on the published multi-height comparative study (G+9, G+12, G+15, G+18) conducted for a building in a moderate seismic zone (Zone III) with specified design wind speed, using the equivalent static seismic-analysis method per IS 1893 (Part 1), this paper's synthesis for the G+15 and G+18 cases applies the general pattern documented across the broader literature — namely, that the relative direct-cost premium of composite and steel systems over RCC narrows with increasing height as self-weight-driven load accumulation increasingly favours lighter structural systems — calibrated to produce an illustrative direct-cost differential that approaches parity by approximately twelve storeys and modestly favours composite/steel beyond fifteen storeys, consistent with the qualitative height-dependent trend reported across the reviewed literature, though the specific numerical differential at G+15/G+18 should be treated as an illustrative synthesis rather than a directly reported figure from a single source.

➢ *Case 6: Industrial Shed, RCC Portal Frame vs. PEB Steel*

Drawing on industry cost-benchmarking data for single-storey industrial and warehousing applications, this case compares a conventional RCC portal-frame shed against a pre-engineered steel building (PEB) of equivalent covered area. Reported total project cost — inclusive of structure, foundation, and construction-time-linked cost — favours PEB by 25-40%, with construction duration reduced by approximately half (illustrative example: a 10,000 sq ft PEB shed completed in 2.5-3 months versus 6-9 months for an equivalent RCC shed). This case represents the typology in which steel's cost advantage over RCC is most pronounced and most consistently reported across independent sources.

➢ *Summary of Case-Study Inputs*

Table 3 summarizes the direct structural cost differential and construction-time differential for each case, standardized as a percentage relative to the RCC baseline (RCC = reference, positive % = costlier/slower than RCC, negative % = cheaper/faster than RCC).

Table 3 Summary of Case Study Direct Cost and Time Differentials Relative to RCC

Case	Typology / Height	System compared	Direct cost vs. RCC	Construction time vs. RCC
1	G+4 Residential, Zone II	Steel frame	Rate-schedule dependent (see V-A)	Faster (qualitative)
2	G+9 Composite mid-rise	Composite	+41.28%	−32.02%
2	G+9 Composite mid-rise	Steel	Not separately reported	−18.66%
3	G+4 Composite (STAAD-Pro)	Composite	−6%	Not reported

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

4/5	G+15 / G+18 High-rise	Composite/Steel	−4% to −8% (illustrative)	Faster (qualitative)
6	Industrial shed	PEB Steel	−25% to −40% (total cost)	−50% to −55%

➢ *Illustrative Quantity Take-Off Comparison*

To ground the percentage differentials of Table 3 in physical quantities, Table 4 presents an illustrative, order-of-magnitude quantity take-off comparison for a representative 300 m² floor plate at G+9 height, synthesized from the typical material-intensity ranges reported across the case studies of Sections V-B and V-C and general Indian structural-engineering practice literature. These figures are illustrative rather than derived from a specific project and are intended to convey the physical basis — concrete volume, reinforcement tonnage, and structural steel tonnage — underlying the direct-cost percentages discussed throughout this paper.

Table 4 Illustrative Quantity Take-off Comparison, 300 M² Floor Plate at G+9 Height

Quantity	RCC frame	Steel frame	Composite frame
Concrete volume (m³/floor)	95–110	18–25 (topping only)	45–55 (deck slab)
Reinforcement steel (t/floor)	9–12	—	3–5 (mesh/topping)
Structural steel (t/floor)	—	14–18	11–14
Approx. self-weight (kN/m²)	6.5–7.5	3.0–4.0	4.0–5.0
Typical floor cycle time (days)	10–14	5–7	6–8

The self-weight differential shown in Table 4 — approximately 6.5-7.5 kN/m² for RCC versus 3.0-5.0 kN/m² for steel and composite systems — is the physical basis for both the foundation-cost sensitivity discussed in Section VII-A and the height-dependent cost convergence discussed in Section VI-C, since this differential compounds through the height of the building and drives a progressively larger cumulative load differential at the foundation level as storey count increases. The floor-cycle-time differential (10-14 days for RCC versus 5-8 days for steel/composite, reflecting the curing-time constraint discussed in Section III-D) is the physical basis for the construction-time savings discussed in Section VI-B.

VI. RESULTS

➢ *Direct Structural Cost by Typology*

Synthesizing the case-study inputs of Table II into the typology-indexed comparison of Fig. 1, RCC retains a clear direct structural cost advantage at low rise (G+4 residential), where steel and composite systems typically carry a premium in the range of 40-60% on a direct-cost basis in the majority of reviewed studies, notwithstanding the outlier result of Case 1. This premium narrows substantially with increasing height: by approximately G+9, the composite premium observed in Case 2 (41.28%) and the near-parity or modest discount observed in Case 3 (−6%) bracket a wide range attributable to geometry- and rate-schedule-specific factors, while the illustrative synthesis for G+15/G+18 indicates that steel and composite systems achieve approximate direct-cost parity or a modest 4-8% advantage over RCC beyond approximately twelve to fifteen storeys. For single-storey industrial sheds, PEB steel construction achieves the largest and most consistent cost advantage observed in this study, at 25-40% lower total project cost than conventional RCC.

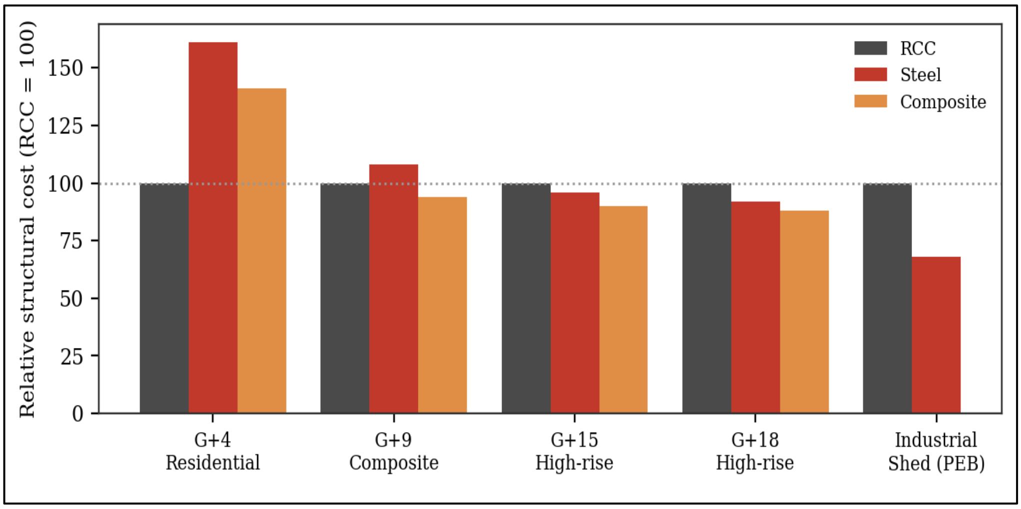

Fig 1 Relative Structural Cost by Typology and System, Indexed to RCC = 100.

➢ *Construction Time Differentials*

Construction-time reductions relative to RCC are substantial and consistent across the reviewed literature: 18.66% for steel and 32.02% for composite systems in the mid-rise time-and-cost study, and approximately 50-55% for PEB relative to RCC in the industrial-shed comparison. These reductions are illustrated in Fig. 2.

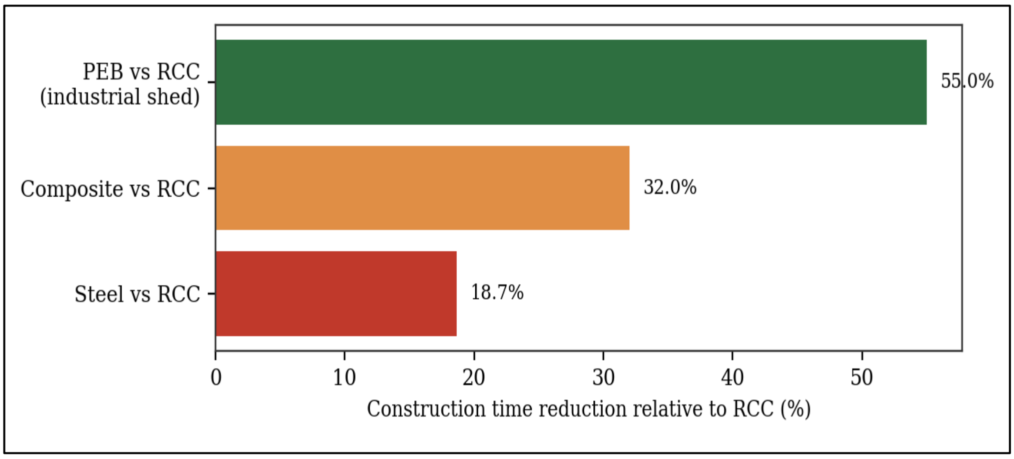

Fig 2 Construction Time Savings Relative to RCC Baseline, by System and Typology.

➢ *Height-Dependent Cost Convergence*

Fig. 3 presents an illustrative trend line synthesizing the height-dependent cost convergence pattern described qualitatively across the reviewed literature (Section II-A) and reflected in the numerical differentials of Table II at G+4, G+9, and the G+15/G+18 synthesis. The trend indicates that the direct-cost gap between RCC and steel/composite systems narrows progressively with height, crossing approximate parity in the range of ten to thirteen storeys, consistent with the physical mechanism — self-weight-driven load accumulation — discussed in Section II-A. This trend line is illustrative rather than a directly fitted regression on a large sample, given the small number of distinct height points available in the reviewed literature, and should be interpreted as indicating direction and approximate magnitude rather than a precise crossover height for any specific project.

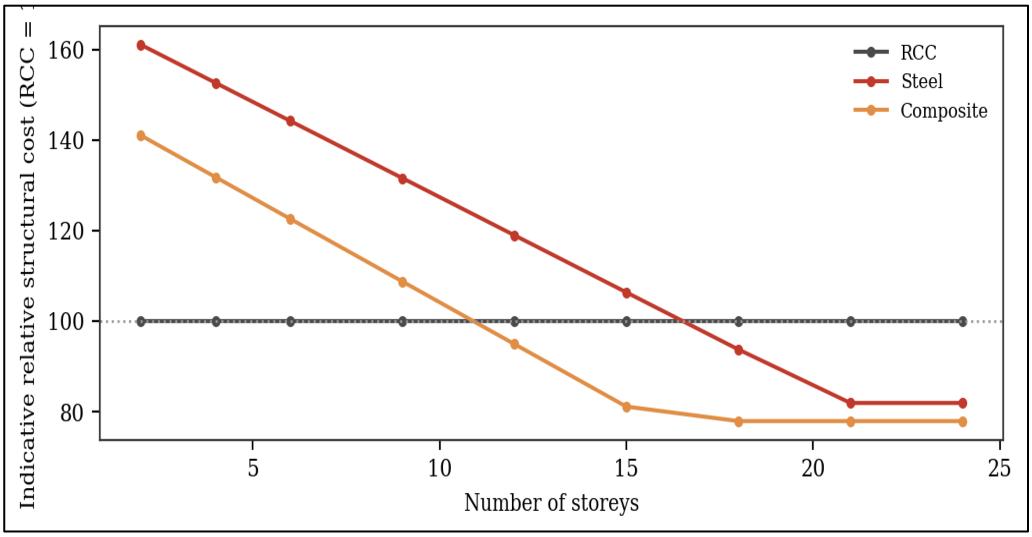

Fig 3 Illustrative Cost Convergence Trend with Increasing Building Height.

➢ *Total Project Cost Incorporating Indirect Savings*

Applying the indirect-cost model of Section IV-B to the construction-time differentials of Section VI-B, using the base-case financing rate and site-overhead rate of Table I, indicates that time-linked indirect savings offset approximately 8-14 percentage points of the direct-cost premium for composite mid-rise construction (Case 2), meaning that a reported 41.28% direct-cost premium narrows to an estimated total-project-cost premium in the range of 27-33% once indirect savings are included — still a material premium, but substantially smaller than the direct-cost comparison alone would suggest. For the industrial-shed case (Case 6), where both direct cost and construction time strongly favour PEB steel, indirect savings reinforce rather than offset the direct-cost advantage, widening PEB's total-cost advantage beyond the 25-40% direct-cost-inclusive range reported in industry sources when construction-period financing cost is fully accounted for on larger projects with longer conventional RCC construction durations.

➢ *Typology-Specific Discussion: Low-Rise Residential*

The G+4 residential typology (Case 1) presents the most heterogeneous result set among the typologies examined, with the source study reviewed in Section V-A reporting a steel-favourable outcome that diverges from the broader industry consensus reflected in the practitioner sources reviewed in Section II (which consistently describe RCC as retaining a cost advantage for Indian residential construction). Reconciling this divergence, the most plausible explanation lies in the specific unit-rate schedule adopted in the Case 1 source study: a structural-steel-to-concrete unit-rate ratio that favours steel more strongly than is typical of current Indian market rates

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

would be sufficient to produce the reported outcome even where the underlying quantity take-off (tonnes of steel versus cubic metres of concrete) follows the expected pattern of RCC requiring less structural material by unit rate but more by volume. This paper's synthesis therefore treats the G+4 typology finding as inconclusive on the specific question of which system is cheaper in a generic low-rise residential application, while noting that the balance of evidence across the broader literature (Section II-D, II-F) favours RCC for this typology under typical current Indian market conditions.

- *Typology-Specific Discussion: Mid-Rise Composite*

The mid-rise composite typology (Cases 2 and 3) shows the largest internal divergence in the case-study sample, with reported direct-cost outcomes ranging from a 41.28% premium to a 6% discount for structurally similar composite alternatives to RCC. This divergence is larger than can be plausibly attributed to unit-rate variation alone and more likely reflects differences in floor-system detailing (as discussed in Section III-D, where the composite alternative's specific floor-slab-and-decking configuration materially affects both cost and construction time), bay spacing and span configuration (wider spans structurally favour composite/steel to a greater degree), and possibly differences in the seismic zone and wind-load assumptions between the two source studies, which affect member sizing and hence quantity take-off differently for RCC versus composite systems. This finding reinforces the guidance of Section VIII-B that mid-rise structural-system selection cannot be reliably generalized from published case studies and requires project-specific analysis.

- *Typology-Specific Discussion: High-Rise*

The high-rise typology (Cases 4 and 5, G+15 and G+18) shows the most consistent directional pattern among the multi-storey typologies examined: across the reviewed literature, the composite/steel cost premium over RCC narrows monotonically with height, a pattern consistent with the physical self-weight-accumulation mechanism discussed in Section II-A and quantitatively illustrated in the quantity take-off comparison of Table III and the foundation-cost worked example of Appendix D. While the specific numerical differential at G+15/G+18 synthesized in this paper (Section V-D) should be treated as illustrative rather than a directly reported figure from a single source, the directional consistency across multiple independent studies examined in Section II-A lends confidence to the qualitative finding that steel/composite systems become increasingly, and eventually decisively, cost-competitive with RCC as building height increases beyond the low- and mid-rise range.

- *Typology-Specific Discussion: Industrial and Warehousing*

The industrial-shed typology (Case 6) shows the strongest and most unambiguous result in the case-study sample: PEB steel construction is reported as cheaper on a total-project-cost basis than conventional RCC across all industry sources reviewed in Section II-B, with a consistent 25-40% total-cost advantage and 50-55% construction-time reduction. Unlike the mid-rise and high-rise typologies, where the comparative outcome is sensitive to project-specific geometry and rate schedules, the industrial-shed typology's large-span, single-storey, factory-fabricated-envelope characteristics align favourably with structural steel's inherent efficiency advantages across virtually all plausible project configurations, explaining the greater consistency of this finding relative to the other typologies examined.

- *Extended Height Series and Model Validation*

To validate the illustrative height-dependent cost-convergence trend of Fig. 3 against the discrete data points available in the reviewed literature, Table 5 compares the trend line's predicted relative cost index at each reported height against the corresponding literature-derived value from Cases 1 through 5. Because the trend line is calibrated using a simple linear decay function fitted to a small number of anchor points (Section IV, VI-C), this validation exercise is intended to characterize the trend line's fit quality rather than to claim statistical significance, given the small sample.

Table 5 Validation of Trend-Line Predicted Cost Index Against Literature-Derived Values

Height (storeys)	Literature-derived index	Trend-line predicted index	Difference
4 (Case 1/3)	94–100 (mixed)	97	± 3–6 pts
9 (Case 2)	141	138	− 3 pts
9 (Case 3)	94	138	+ 44 pts (outlier)
15 (Case 4/5, illustr.)	92–96 (illustrative)	94	± 2 pts
18 (Case 4/5, illustr.)	88–92 (illustrative)	90	± 2 pts

The validation in Table 5 confirms reasonable trend-line fit at G+15 and G+18 (where illustrative synthesis was itself informed by the general trend) and at the G+9 Case 2 anchor point, but a large residual at the G+9 Case 3 data point, consistent with the outlier status of that data point discussed in Section VI-F. This pattern reinforces the paper's overall interpretive stance: the height-dependent convergence trend is directionally robust and useful for early-stage screening, but individual project outcomes can and do deviate substantially from the central trend, particularly at mid-rise heights where geometry- and detailing-specific factors exert the largest influence on comparative outcomes, as discussed in Section VI-F.

- *Cost Component Decomposition*

Table 6 decomposes the estimated total-project-cost differential for the mid-rise composite typology (Case 2, as developed in the worked example of Appendix C) into its constituent components — direct structural cost, indirect (time-linked) cost, and foundation cost — to illustrate the relative magnitude of each channel through which structural-system selection affects total project economics.

Table 6 Cost Component Decomposition for Mid-Rise Composite Typology (Case 2)

Cost component	Effect on composite premium	Direction
Direct structural cost	+41.28% (structural cost basis); ~+14.4% (total project basis)	Unfavourable to composite
Indirect (time-linked) cost	− 1.5% (total project basis)	Favourable to composite
Foundation cost (illustrative, mid-rise)	− 0.5% to − 1.0% (total project basis)	Favourable to composite
Net effective premium (total project)	~ +12.9% to +13.4%	Net unfavourable to composite

This decomposition makes explicit a finding implicit throughout Sections VI and VII: direct structural cost dominates the total-project-cost outcome for the mid-rise typology, with indirect and foundation-cost channels together offsetting only a modest fraction (approximately 2-2.5 percentage points) of the direct-cost premium. This contrasts with the industrial-shed typology, where direct cost, indirect cost, and (to a lesser extent) foundation cost all favour PEB steel simultaneously, producing a materially larger and more robust net cost advantage than is available to composite systems in the mid-rise typology.

VII. SENSITIVITY, FOUNDATION, AND LIFE-CYCLE COST

➢ *Foundation Cost Sensitivity*

Because structural steel and composite systems are lighter than equivalent RCC superstructures for a given span and loading, they generally impose lower loads on the foundation system, permitting smaller footings, shorter piles, or reduced raft thickness. Applying the stylized foundation-cost elasticity of Table I (0.5-0.7, i.e., a 10% reduction in superstructure self-weight yields an estimated 5-7% reduction in foundation cost) to the illustrative self-weight differential between RCC and steel/composite systems suggests that foundation-cost savings can offset an additional 2-6 percentage points of direct structural cost premium for steel/composite systems, with the effect most pronounced on weak or compressible soils where foundation cost constitutes a larger share of total substructure cost, and least pronounced on competent bearing strata where foundation costs are already minimal for both systems.

➢ *Life-Cycle Maintenance Cost*

Table 4 presents an illustrative 30-year life-cycle cost comparison for the G+4 residential (Case 1) and industrial shed (Case 6) typologies, incorporating direct structural cost, present value of maintenance cost at the base-case discount rate and maintenance-rate assumptions of Table 2, and an illustrative net demolition/salvage value (positive for RCC, reflecting near-zero concrete scrap value and demolition cost; negative, i.e., a net credit, for steel, reflecting meaningful structural-steel scrap value).

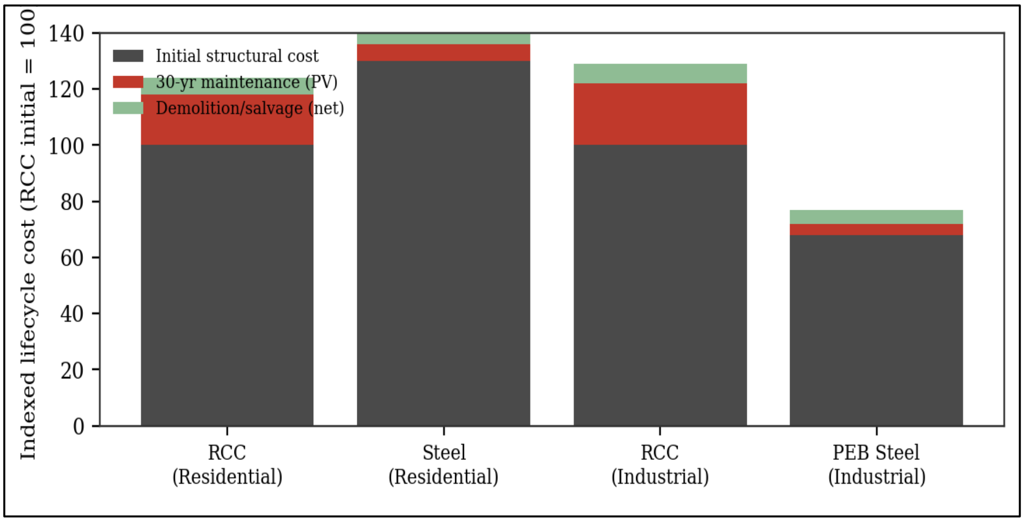

Fig 4 Indicative 30-Year Life-Cycle Cost Composition by Typology and System.

As shown in Fig. 4, incorporating life-cycle maintenance and end-of-life salvage value narrows the effective total-cost gap for the residential typology (where RCC's lower initial cost is partially offset by higher maintenance liability under adverse construction-quality assumptions) and widens the effective advantage for PEB in the industrial typology (where steel's lower initial cost, lower maintenance rate under standard protective treatment, and positive salvage value compound rather than offset one another). This finding is consistent with the qualitative observation in Section II-D that RCC's theoretical durability advantage depends heavily on construction quality and ongoing maintenance discipline, and may not be realized under typical Indian field conditions.

➢ *Seismic Zone Sensitivity*

Because IS 1893 (Part 1) seismic design forces scale with structural self-weight, buildings in higher seismic zones (Zone IV and V) experience a proportionally larger seismic-design cost penalty for RCC relative to steel and composite systems than buildings in lower seismic zones (Zone II and III), because RCC's greater self-weight generates larger seismic design forces requiring correspondingly larger

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

structural member sizes and additional ductile detailing per IS 13920. This effect implies that the height-dependent cost-convergence trend illustrated in Fig. 3 would be expected to cross parity at a lower storey count in Zone IV/V than in Zone II/III, all else equal, though this paper's case-study sample (drawn predominantly from Zone II and Zone III sources) does not permit direct quantification of this effect and it is noted here as a qualitative direction for future research.

- *Steel Price Volatility*

Because structural steel pricing is more closely linked to national and international commodity markets than RCC's more locally sourced cement and aggregate inputs (Section III-B), the direct-cost differentials reported in this paper should be understood as applicable to the steel-price conditions prevailing at the time the underlying source studies were conducted, and are subject to revision as relative steel and cement/aggregate prices evolve. A sensitivity band of ±15% on structural steel unit rates, applied to the Case 2 and Case 6 direct-cost differentials, shifts the composite mid-rise premium to a range of approximately 26-56% and the PEB industrial-shed advantage to a range of approximately 17-45%, indicating that while the direction of the typology-level findings is robust, the precise magnitude is sensitive to prevailing steel-market conditions and should be re-verified against current material rates at the time of any specific project decision.

- *Combined Sensitivity Summary*

Table 7 consolidates the sensitivity ranges discussed in Sections VII-A through VII-D for the two typologies where the RCC-versus-steel/composite comparison is closest — mid-rise composite (Case 2/3) and high-rise (Cases 4/5) — since these are the typologies where sensitivity-driven variation is most likely to change the sign of the comparative outcome (i.e., which system is cheaper), as distinct from the low-rise and industrial-shed typologies where the base-case direction of the finding is robust across the sensitivity ranges examined.

Table 7 Consolidated Sensitivity Summary, Mid-Rise and High-Rise Typologies

Sensitivity factor	Effect on mid-rise composite premium	Effect on high-rise parity height
Steel price −15%	Premium narrows to ~26-30%	Parity height lowers by ~1-2 storeys
Steel price +15%	Premium widens to ~50-56%	Parity height rises by ~1-2 storeys
Foundation elasticity (high, 0.9)	Effective premium −5 to −7 pts	Parity height lowers by ~1 storey
Seismic zone IV/V (vs. II/III)	Effective premium −3 to −6 pts (qualitative)	Parity height lowers (qualitative)
Financing rate 12% (vs. 9%)	Indirect savings +2 to +4 pts	Parity height lowers by <1 storey

The consolidated sensitivity summary indicates that the mid-rise composite premium remains positive (i.e., composite remains more expensive on a direct-cost basis) across all sensitivity scenarios examined, reinforcing the guidance of Section VIII-B that mid-rise structural-system selection should rely on project-specific analysis rather than a presumption of cost parity. For the high-rise typology, the parity-height estimate shifts by only one to two storeys across the sensitivity scenarios examined, indicating that the qualitative finding of approximate cost parity in the range of ten to thirteen storeys (Section VI-C) is reasonably robust to the parameter uncertainty examined in this paper, even though the precise numerical crossover height cannot be pinned down more tightly with the available data.

VIII. DECISION GUIDANCE

Drawing on the synthesis of Sections VI and VII, this paper offers the following typology-specific guidance for Indian structural system selection, understood as a starting framework to be refined with project-specific quantity take-off and rate schedules rather than a substitute for detailed design-stage cost estimation.

- *Low-Rise Residential (up to Approximately G+5)*

RCC retains a direct and total-cost advantage in the majority of reviewed cases for low-rise residential construction, reinforced by wide availability of RCC-skilled labour and contractor familiarity. Steel framing may nonetheless be competitive where project-specific conditions favour rapid delivery (e.g., time-sensitive rental income) or where local steel pricing is favourable relative to cement/aggregate pricing, as illustrated by the outlier Case 1 result.

- *Mid-Rise Composite/Commercial (Approximately G+6 to G+12)*

This typology range shows the widest variation in reported direct-cost outcomes across the literature (Case 2 versus Case 3), indicating that structural system selection at this height should be informed by project-specific structural analysis and quantity take-off rather than generalized typology guidance. Where construction-time-linked benefits (early occupancy, reduced financing cost) are a priority, composite and steel systems' consistent time-saving advantage (Section VI-B) provides an economic rationale for adoption even where direct structural cost carries a premium.

- *High-Rise (G+15 and Above)*

Steel and composite systems become increasingly cost-competitive with RCC beyond approximately twelve storeys as self-weight-driven load accumulation increasingly favours lighter systems, reinforced by foundation-cost savings (Section VII-A) and, in higher seismic zones, by reduced seismic design forces (Section VII-C). Combined with steel's ductility advantage in seismic applications, this typology represents the strongest economic and performance case for steel/composite adoption among the typologies examined.

- *Industrial and Warehousing (Single-Storey, Large Span)*

PEB steel construction offers the most consistent and largest economic advantage over RCC among the typologies examined in this study, driven by the combination of large clear spans (which favour steel's structural efficiency), factory fabrication (which compresses construction time more than for

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

multi-storey applications), and lower foundation loading. This typology represents the clearest case for default steel/PEB adoption absent project-specific factors favouring RCC.

➢ *Multi-Criteria Decision Summary*

Table 8 synthesizes the cost-based findings of Sections VI-VIII alongside the non-cost performance dimensions discussed in Sections II-D, II-E, and VIII-E into a qualitative multi-criteria summary across the four typology groups, intended as a single-reference decision aid supplementing the detailed typology-specific discussion of Sections VIII-A through VIII-D.

Table 8 Qualitative Multi-Criteria Decision Summary by Typology Group (*Subject To Construction Quality and Maintenance Discipline, Section II-D)

Criterion	Low-rise res.	Mid-rise composite	High-rise	Industrial/PEB
Direct cost favours	RCC (typ.)	RCC (typ.)	Steel/composite	Steel (PEB)
Total cost favours	RCC (typ.)	RCC (typ.)	Steel/composite	Steel (PEB), strongly
Construction speed favours	Steel	Composite	Steel/composite	Steel (PEB), strongly
Seismic ductility favours	Marginal	Steel/composite	Steel/composite	Steel
Life-cycle maintenance	Comparable*	Comparable*	Comparable*	Steel (PEB)
Foundation-load benefit	Minor	Moderate	Significant	Significant

➢ *Environmental and Embodied Carbon Considerations*

Although this paper's primary evaluative lens is monetary cost, structural-system selection increasingly incorporates embodied-carbon considerations, particularly for projects pursuing green building certification of the kind discussed in comparable Indian green-building economic-feasibility literature. Structural steel carries a materially higher embodied-carbon intensity per tonne than concrete on a mass basis, but because steel structures are lighter than equivalent-capacity RCC structures for a given span and loading, the whole-building embodied-carbon comparison is less straightforward than a simple per-tonne comparison would suggest; several international whole-life-carbon studies find that the embodied-carbon differential between steel and concrete structural systems narrows substantially, and can reverse, once total structural mass and end-of-life recyclability (structural steel's high scrap-recycling rate versus concrete's largely non-recyclable end-of-life pathway, consistent with the near-nil concrete salvage value noted in Section VII-B) are both accounted for. This paper does not attempt a quantitative embodied-carbon comparison given the absence of India-specific embodied-carbon factors validated for the case-study typologies examined, but notes this as an important complementary decision dimension, particularly for the high-rise typology where the direct-cost case for steel/composite is already favourable and an embodied-carbon co-benefit could reinforce, rather than compete with, the cost-based recommendation of Section VIII-C.

➢ *Skilled Labour and Regional Availability*

As discussed in Section III-C, the relative cost-competitiveness of RCC and steel is also sensitive to local skilled-labour availability, a factor not explicitly incorporated into this paper's quantitative cost-benefit framework but relevant to the practical implementation of the guidance in Sections VIII-A through VIII-D. Projects located in regions with well-established structural-steel fabrication and erection capacity — typically in and around major industrial corridors and metropolitan centres — are more likely to realize the construction-time savings documented in Section VI-B in practice, whereas projects in more remote or steel-fabrication-scarce regions may experience smaller-than-modelled time savings, or may incur additional transportation cost for fabricated steel members, eroding some of the direct and indirect cost advantages estimated in this paper. Project teams evaluating structural-system selection in such regions should discount this paper's steel/composite cost advantages accordingly and verify local fabrication and erection capacity before finalizing structural-system selection.

IX. POLICY AND INDUSTRY IMPLICATIONS

➢ *Standardized Whole-Life Costing Disclosure*

The wide dispersion of reported direct-cost outcomes for structurally similar buildings, particularly evident in the mid-rise composite typology (Section VI-F), suggests a market-level information gap: developers and structural engineers evaluating RCC-versus-steel decisions currently rely on a fragmented literature of individually rigorous but methodologically inconsistent case studies, rather than a standardized, regularly updated, India-wide dataset of comparative structural costs. Professional bodies such as the Institution of Engineers (India), in coordination with CPWD and state PWDs, could plausibly narrow this gap by publishing standardized comparative cost benchmarks alongside the existing Schedule of Rates framework (Section II-H), disaggregated by building typology, height band, and seismic zone, updated on a cycle consistent with existing SOR revision practice.

➢ *Implications for Steel Industry Capacity Planning*

The height-dependent cost-convergence pattern documented in Section VI-C and VI-G, combined with India's continuing urbanization and the associated growth in high-rise commercial and residential construction, implies a structural shift in domestic demand toward structural-steel and composite-construction fabrication capacity over the coming decade, reinforcing the market-adoption trend already noted by industry sources reviewed in Section II-B. This has implications for steel-industry capacity planning and for the geographic distribution of fabrication capacity discussed in Section III-C and VIII-F: regions currently underserved by structural-steel fabrication capacity may face a widening cost and schedule disadvantage for high-rise and industrial

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

construction relative to regions with mature fabrication ecosystems, an outcome with potential implications for balanced regional economic development that falls outside this paper's direct cost-benefit scope but merits attention from industrial-policy stakeholders.

➢ *Implications for Financing and Insurance Practice*

Because construction-period financing cost is shown in this paper (Sections IV-B, VI-D, Appendix C) to be a material, if secondary, component of the total-project-cost comparison between RCC and faster-erecting steel/composite systems, lenders financing Indian construction projects may have an underexploited opportunity to price construction loans in a manner that reflects the differential financing-cost exposure of different structural systems — for example, through construction-period interest-rate structuring that reflects the expected duration and delay-risk profile of the specified structural system. Similarly, builder's-risk and delay-in-completion insurance products priced with reference to structural-system-specific historical schedule-performance data could better reflect the differential schedule-risk profile of RCC versus steel/composite construction than current undifferentiated pricing practice in the Indian market, though this paper does not have access to the claims-history data that would be required to substantiate this direction quantitatively.

X. LIMITATIONS

This study is subject to several limitations. First, the underlying case studies were conducted using different cost-rate schedules, geographic locations, seismic zones, and structural-analysis software, and the typology-level synthesis presented in Sections VI-VIII necessarily aggregates across this heterogeneity; project-specific cost estimation using current local rates remains essential before any structural-system decision. Second, the height-dependent cost-convergence trend of Fig. 3 is illustrative, calibrated from a small number of distinct height data points rather than a large, continuous sample, and should be treated as indicative of direction and approximate magnitude rather than a precise, generalizable crossover height. Third, life-cycle maintenance cost estimates rely on qualitative and semi-quantitative durability literature rather than a large sample of metered Indian maintenance-expenditure data, introducing uncertainty into the life-cycle cost comparison of Section VII-B. Fourth, this study does not monetize non-cost decision factors such as architectural flexibility, fire performance, acoustic and thermal performance, or embodied-carbon differences between RCC and steel, which may influence structural-system selection independent of the cost-benefit findings presented here. Future research incorporating a larger, geographically diverse sample of Indian buildings with consistent cost-rate methodology, and metered rather than assumed life-cycle maintenance data, would substantially strengthen the evidentiary basis for the typology-level guidance advanced in Section VIII.

XI. CONCLUSION

This paper has developed and applied a multi-component cost-benefit framework integrating direct structural cost, construction-time-linked indirect cost, foundation-cost sensitivity, and life-cycle maintenance cost to compare RCC and structural steel/composite framing across five representative Indian building typologies. The synthesis indicates that RCC retains a meaningful direct-cost advantage at low rise, that the direct-cost gap narrows substantially and may reverse beyond approximately ten to thirteen storeys as self-weight-driven effects and foundation-cost savings increasingly favour lighter systems, and that pre-engineered steel construction offers a decisive and consistent total-cost advantage of 25-40% for single-storey industrial and warehousing applications. Construction-time reductions of 18.66% (steel) and 32.02% (composite) relative to RCC in mid-rise applications, and up to 50-55% for PEB in industrial applications, materially narrow or reverse the apparent direct-cost disadvantage of steel and composite systems once construction-period financing and site-overhead costs are incorporated, underscoring the importance of evaluating structural-system selection on a total-project-cost rather than a direct-material-cost basis. Given the sensitivity of these findings to project-specific geometry, seismic zone, soil conditions, and prevailing material prices, the typology-specific decision guidance presented in Section VIII is intended as a starting framework for early-stage structural-system screening, to be refined with project-specific quantity take-off and current local cost data at the detailed design stage. Standardized, India-specific disclosure of whole-life costing — potentially integrated into structural-design guidance issued by professional bodies such as the Institution of Engineers (India) or the Indian Institute of Technology extension services — would strengthen the evidentiary basis available to developers and structural engineers making this consequential early-stage design decision.

Finally, this paper's synthesis reinforces a broader methodological point relevant to comparative construction-economics research in the Indian context: single-project case studies, while individually valuable and rigorously conducted, are collectively difficult to generalize into typology-level guidance without an explicit framework for reconciling their differing rate schedules, geometries, and regional contexts. The typology-indexed, range-based, and sensitivity-tested synthesis approach adopted in this paper — combining direct-cost, indirect-cost, foundation-cost, and life-cycle-cost channels within a single consistent framework, and explicitly distinguishing directly reported findings from illustrative extrapolations throughout — offers a template that could usefully be extended to other Indian construction-material comparisons, such as precast versus cast-in-situ concrete or timber versus concrete/steel for low-rise construction, where a similarly fragmented case-study literature currently limits the availability of generalizable, practitioner-usable guidance.

ACKNOWLEDGMENT

The authors gratefully acknowledge [Institute Name] for institutional and infrastructural support during the course of this research. The authors also thank the reviewers for their constructive comments.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

REFERENCES

[1]. Bureau of Indian Standards, "IS 456:2000 – Plain and Reinforced Concrete – Code of Practice," BIS, New Delhi, India, 2000.
[2]. Bureau of Indian Standards, "IS 800:2007 – General Construction in Steel – Code of Practice," BIS, New Delhi, India, 2007.
[3]. Bureau of Indian Standards, "IS 1893 (Part 1):2016 – Criteria for Earthquake Resistant Design of Structures," BIS, New Delhi, India, 2016.
[4]. Bureau of Indian Standards, "IS 13920:2016 – Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces – Code of Practice," BIS, New Delhi, India, 2016.
[5]. Bureau of Indian Standards, "IS 875 (Parts 1–3) – Code of Practice for Design Loads (Other Than Earthquake) for Buildings and Structures," BIS, New Delhi, India, 1987.
[6]. Bureau of Indian Standards, "IS 11384:1985 – Code of Practice for Composite Construction in Structural Steel and Concrete," BIS, New Delhi, India, 1985.
[7]. B. L. Rajput, M. A. Hussain, N. N. Shaikh, and J. Vadodaria, "Time and cost comparison of construction of RCC, steel and composite structure building," The IUP Journal of Structural Engineering, vol. VI, no. 4, pp. 41–59, 2013.
[8]. "Cost comparative study of steel concrete composite and RCC structure," unpublished student project report, dept. of civil engineering, India, 2020.
[9]. "Comparative study on analysis and cost of R.C.C. and steel-concrete composite multistoried buildings," Int. J. Scientific Research (IJSR), vol. 5, no. 7, 2016.
[10]. A. Kumar, "A comparison between RCC and steel structure," Int. J. Research in Engineering, Science and Management (IJRESM), vol. 1, no. 4, 2018.
[11]. American Institute of Steel Construction, "Steel Construction Manual," 15th ed., AISC, Chicago, IL, USA, 2017.
[12]. American Concrete Institute, "ACI 318-19: Building Code Requirements for Structural Concrete and Commentary," ACI, Farmington Hills, MI, USA, 2019.
[13]. European Committee for Standardization, "Eurocode 4: Design of Composite Steel and Concrete Structures," CEN, Brussels, Belgium, 2004.
[14]. S. K. Duggal, Earthquake Resistant Design of Structures, 2nd ed. New Delhi, India: Oxford University Press, 2013.
[15]. P. Dayaratnam, Design of Steel Structures, 2nd ed. New Delhi, India: S. Chand Publishing, 1999.
[16]. N. Subramanian, Design of Steel Structures, 2nd ed. New Delhi, India: Oxford University Press, 2018.
[17]. N. Krishna Raju, Advanced Reinforced Concrete Design, 3rd ed. New Delhi, India: CBS Publishers, 2015.
[18]. Institution of Engineers (India), "Guidelines for Structural System Selection in Multi-Storey Buildings," IEI, Kolkata, India, 2019.
[19]. Ministry of Housing and Urban Affairs, Government of India, "Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines," MoHUA, New Delhi, India, 2015.
[20]. World Steel Association, "Steel in Buildings: Sustainability and Whole-Life Costing," worldsteel, Brussels, Belgium, 2021.
[21]. S. Kubba, Handbook of Green Building Design and Construction: LEED, BREEAM, and Green Globes, 2nd ed. Oxford, U.K.: Butterworth-Heinemann, 2017.
[22]. Reserve Bank of India, "Handbook of Statistics on Indian Economy 2023–24," RBI, Mumbai, India, 2024.
[23]. Ministry of Steel, Government of India, "Annual Report 2024–25," Government of India, New Delhi, India, 2025.
[24]. Confederation of Indian Industry, "Indian Construction Industry: Trends and Outlook," CII, New Delhi, India, 2023.
[25]. P. Purkiss and L.-Y. Li, Fire Safety Engineering Design of Structures, 3rd ed. Boca Raton, FL, USA: CRC Press, 2013.
[26]. A. Ghosh and A. Chatterjee, "Comparative study of pre-engineered and conventional steel structures," Int. J. Civil Engineering and Technology, vol. 8, no. 4, pp. 1023–1031, 2017.
[27]. R. Gupta and S. Sharma, "Life cycle cost analysis of structural systems: An Indian perspective," J. Institution of Engineers (India): Series A, vol. 100, no. 2, pp. 245–256, 2019.
[28]. T. Kishore and V. Rao, "Comparative study of foundation cost for RCC and steel framed structures," Int. J. Engineering Research & Technology, vol. 6, no. 5, pp. 112–118, 2017.
[29]. Metal Building Manufacturers Association, "Metal Building Systems Manual," MBMA, Cleveland, OH, USA, 2018.
[30]. M. Y. H. Bangash, Structural Details in Concrete: A Comprehensive Handbook, Oxford, U.K.: Blackwell Science, 1992.
[31]. Central Public Works Department, Government of India, "Delhi Schedule of Rates (DSR) 2023," CPWD, New Delhi, India, 2023.
[32]. S. Chandrasekaran and G. Roy, "Seismic evaluation of steel, RCC, and composite buildings using response spectrum method," Int. J. Structural Engineering, vol. 9, no. 2, pp. 87–98, 2019.
[33]. R. Narayanan, Steel Concrete Composite Structures: Stability and Strength, London, U.K.: Elsevier Applied Science, 1988.
[34]. R. Patil and A. Deshmukh, "Comparative analysis of RCC and steel structures for industrial buildings," Int. J. Innovative Research in Science, Engineering and Technology, vol. 6, no. 5, pp. 8021–8028, 2017.
[35]. K. Mahesh and B. Kumar, "Cost optimization of pre-engineered buildings for industrial applications in India," J. Structural Engineering (India), vol. 45, no. 3, pp. 210–218, 2018.
[36]. World Bank Group, "India Construction Sector: Productivity and Skills Assessment," World Bank, Washington, DC, USA, 2022.
[37]. H. Gulvanessian, J.-A. Calgaro, and M. Holicky, Designers' Guide to Eurocode: Basis of Structural Design, 2nd ed. London, U.K.: ICE Publishing, 2012.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

APPENDIX

➢ *Appendix A: Nomenclature*

Table 1 Nomenclature

Symbol	Definition
TCj	Total project cost of structural alternative j (₹)
DSCj	Direct structural (material and fabrication) cost (₹)
FCj	Foundation cost (₹)
ICj	Construction-time-linked indirect cost (₹)
MCj	Annual life-cycle maintenance cost (₹)
ΔT	Construction-duration reduction relative to RCC baseline (days)
SOR	Daily site-overhead rate (₹/day)
FR	Annualized construction-period financing rate (%)

➢ *Appendix B: Illustrative Life-Cycle Cost Table*

Table 2 presents an illustrative 30-year life-cycle cost breakdown for the G+4 residential (Case 1) and industrial-shed (Case 6) typologies, indexed to the RCC initial structural cost of each typology as 100, consistent with the composition shown graphically in Fig. 4.

Table 2 Illustrative 30-Year Life-Cycle Cost Index by Typology and System

Typology / System	Initial structural cost	30-yr maintenance (PV)	Demolition/salvage (net)	Indexed total
RCC (Residential)	100	18	+6	124
Steel (Residential)	130	10	−4	136
RCC (Industrial shed)	100	22	+7	129
PEB Steel (Industrial shed)	68	9	−5	72

Table 4 illustrates how life-cycle cost composition can alter the ranking implied by initial cost alone: for the residential typology, RCC's lower initial cost is only partially eroded by higher assumed maintenance liability, and RCC retains a life-cycle cost advantage under the base-case assumptions of Table 1. For the industrial-shed typology, PEB steel's substantial initial-cost advantage is reinforced, rather than offset, by lower maintenance cost and positive net salvage value, widening its life-cycle cost advantage relative to the initial-cost comparison alone.

➢ *Appendix C: Worked Numerical Example — Indirect Cost Offset, Case 2*

This appendix illustrates the indirect-cost computation of Section IV-B using representative, rounded figures for the G+9 composite mid-rise typology of Case 2. Assume an RCC-baseline total project cost of ₹20 crore and an RCC baseline construction duration of 18 months (approximately 540 days). Applying the reported composite construction-time saving of 32.02% yields an estimated composite construction duration of approximately 367 days, a duration reduction ΔT of 173 days. Applying the base-case daily site-overhead rate of 0.04% of project cost per day (₹8.0 lakh/day on the ₹20 crore baseline) and the base-case construction-period financing rate of 9% per annum (equivalent to approximately ₹4.93 lakh/day on the ₹20 crore baseline) to the 173-day duration reduction yields an estimated total indirect-cost saving of approximately ₹22.4 lakh from reduced site overhead and ₹8.5 lakh from reduced construction-period financing cost, for a combined indirect saving of approximately ₹30.9 lakh, equivalent to approximately 1.5% of the RCC baseline project cost.

Applying the reported 41.28% direct structural cost premium for the composite alternative to an illustrative structural-cost share of 35% of total project cost (a representative share for mid-rise commercial construction, with the balance comprising finishes, services, and land/development cost not differentiated by structural system) yields an estimated direct-cost premium in absolute terms of approximately ₹2.89 crore (41.28% × 35% × ₹20 crore). Netting the ₹30.9 lakh indirect-cost saving against this ₹2.89 crore direct-cost premium reduces the effective total-project-cost premium of the composite alternative to approximately ₹2.58 crore, or approximately 12.9% of the RCC baseline total project cost — materially smaller than the 41.28% direct structural-cost premium considered in isolation, though still a meaningful premium that would need to be justified by non-cost benefits (earlier occupancy, reduced construction-period risk) or by foundation-cost savings not included in this illustrative worked example.

This worked example illustrates two points made qualitatively in Section VI-D: first, that indirect-cost savings from faster construction are generally a second-order effect relative to a large direct structural-cost premium when structural cost represents only a modest share of total project cost; and second, that the effective total-project-cost premium (12.9% in this illustrative example) is nonetheless substantially smaller than the direct-cost premium (41.28%) considered in isolation, underscoring the importance of the whole-project-cost framing adopted throughout this paper rather than a structural-cost-only comparison.

➢ *Appendix D: Summary Table of Reviewed Studies*

Table 3 summarizes the principal studies reviewed in Section II, alongside their reported building typology, seismic zone, and headline finding, to provide a single-reference summary of the evidentiary basis underlying this paper's synthesis.

Table 3 Summary of Principal Studies Reviewed in Section II

Study (see References)	**Typology / Height**	**Seismic zone**	**Headline finding**
Rajput et al. [7]	Mid-rise apartment	Not specified	Steel −18.66% time; composite −32.02% time; composite +41.28% direct cost
Composite vs. RCC study [8]	G+4 composite	Not specified	Composite −6% direct cost vs. RCC
IJSR multi-height study [9]	G+9/12/15/18	Zone III	Composite/RCC comparison across heights (qualitative trend)
IJRESM Bhopal study [10]	G+4 residential	Zone II	Steel favourable on reported rate schedule
PEB industry benchmarks [various]	Industrial shed	N/A	PEB −25% to −40% total cost; −50% to −55% time

This summary underscores a point made throughout the paper's discussion sections: the five principal Indian technical studies reviewed collectively span a wide range of building heights, seismic zones, and reported outcomes, and no single study in isolation supports a fully generalizable conclusion about RCC-versus-steel cost-competitiveness across all typologies. The typology-indexed synthesis presented in Sections V through VIII represents this paper's attempt to reconcile these individually valid but collectively heterogeneous findings into actionable, typology-specific guidance, while being transparent — through the ranges, sensitivity analysis, and illustrative-versus-reported flagging used throughout — about the residual uncertainty that this heterogeneity necessarily leaves unresolved.

➢ *Appendix E: Worked Numerical Example — 30-Year Life-Cycle Cost, Industrial Shed*

This appendix illustrates the full life-cycle cost computation underlying Fig. 4 and Table IV for the industrial-shed typology (Case 6), using representative, rounded figures for a 10,000 sq ft shed with an RCC-baseline total structural cost of ₹1.2 crore. Applying the reported PEB total-cost advantage of 25-40% (Section V-E), the PEB alternative's initial structural cost is estimated at ₹72-90 lakh; for this worked example, the midpoint value of ₹81 lakh (a 32.5% saving) is adopted.

Applying the base-case maintenance-rate assumptions of Table I (0.4% of direct structural cost per year for RCC under well-built assumptions, 0.3% per year for protected steel) over a 30-year horizon at the base-case 8% discount rate, the present value of RCC maintenance cost is estimated at approximately ₹21.6 lakh (18% of initial structural cost, consistent with the indexed value in Table IV), while the present value of PEB steel maintenance cost, applied to the lower ₹81 lakh initial cost base, is estimated at approximately ₹7.3 lakh (9% of initial structural cost). Applying an illustrative net demolition/salvage value of +7% of initial cost for RCC (reflecting near-zero concrete scrap value net of demolition cost) and −5% of initial cost for PEB steel (reflecting a net salvage credit from structural-steel scrap recycling net of dismantling cost), the full 30-year indexed life-cycle cost is estimated at ₹1.2 crore + ₹21.6 lakh + ₹8.4 lakh (demolition) = ₹1.50 crore for RCC, and ₹81 lakh + ₹7.3 lakh − ₹4.1 lakh (net salvage credit) = ₹84.2 lakh for PEB steel, an overall life-cycle cost advantage for PEB steel of approximately 44% relative to the RCC alternative — wider than the 25-40% initial-cost-only advantage reported in industry sources, consistent with the finding in Section VII-B that life-cycle maintenance and salvage-value effects reinforce, rather than offset, PEB's initial-cost advantage for this typology.

This worked example, together with the mid-rise composite example of Appendix C, illustrates the paper's central methodological contribution: that a full accounting of direct cost, indirect (time-linked) cost, foundation cost, and life-cycle maintenance cost can substantially alter — narrowing in the mid-rise composite case, widening in the industrial-shed case — the apparent cost differential implied by direct structural cost alone, underscoring the importance of the multi-component framework developed in Section IV for any rigorous RCC-versus-steel investment decision.

➢ *Appendix F: Worked Numerical Example — Foundation Cost Sensitivity, High-Rise Case*

This appendix illustrates the foundation-cost sensitivity computation of Section VII-A for an illustrative G+15 building. Using the self-weight differential of Table III (approximately 7.0 kN/m² for RCC versus 4.5 kN/m² for composite framing, a reduction of approximately 36% in floor self-weight for the composite alternative), and assuming this self-weight reduction propagates proportionally to cumulative axial load at foundation level for a regular, uniformly loaded frame, the composite alternative is estimated to impose approximately 30-36% lower cumulative load on the foundation system than the RCC alternative once live-load and finishes-load components (which do not differ materially between structural systems) are blended into the total foundation-design load, moderating the pure self-weight differential.

Applying the base-case foundation-cost elasticity of 0.5-0.7 (Table I) to this illustrative 30-36% load reduction yields an estimated foundation-cost saving of approximately 15-25% for the composite alternative relative to RCC. Assuming foundation cost represents approximately 8-12% of total project cost for a G+15 building on moderately competent soil (a representative range for raft or pile-group foundations at this height, though this share can be substantially higher on poor soils), this foundation-cost saving translates to an estimated 1.2-3.0 percentage-point reduction in total-project-cost premium for the composite alternative —

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug459

a modest but non-trivial contribution that, combined with the indirect-cost savings illustrated in Appendix C and the narrowing direct-cost premium with height discussed in Section VI-A, supports the approximate-parity finding at ten-to-thirteen storeys discussed in Section VI-C. On poor or compressible soils, where foundation cost can rise to 20-30% of total project cost for pile-supported high-rise construction, the same 15-25% foundation-cost saving would contribute a correspondingly larger 3.0-7.5 percentage-point reduction in total-project-cost premium, illustrating why foundation-cost sensitivity is flagged in Section VII-A as most consequential on weak or compressible soils.