Prefabricated vs Cast-in-Place Structures: A Life-Cycle Cost Whitepaper

1. Executive Summary

Buyers comparing prefabricated steel structures against cast-in-place reinforced concrete usually compare first-cost only - and often on incomplete data. This whitepaper presents a life-cycle cost (LCC) framework covering capital cost, schedule and financing, quality and rework, maintenance, deconstruction, and carbon. The conclusion is context-dependent but robust: for clear spans above 20-24 m, weak soils, accelerated programmes, or buildings that may be extended or relocated, prefabricated steel delivers a lower total cost of ownership than cast-in-place concrete in the majority of typical commercial and industrial cases.

> **This paper uses indicative ranges drawn from international benchmark data (RS Means, published academic LCC studies and EPC tender records). Site-specific figures vary with labour rates, material indices and local codes - the framework, not the absolute numbers, is the deliverable.**

2. Life-Cycle Cost Model

LCC(C) = C_capital + C_finance + C_operation + C_maintenance + C_end-of-life - C_residual. Each component is discounted to present value. Omitting any one of the five components - especially finance cost and residual value - systematically biases the comparison against steel.

Typical LCC composition - prefab steel, 25-year horizon

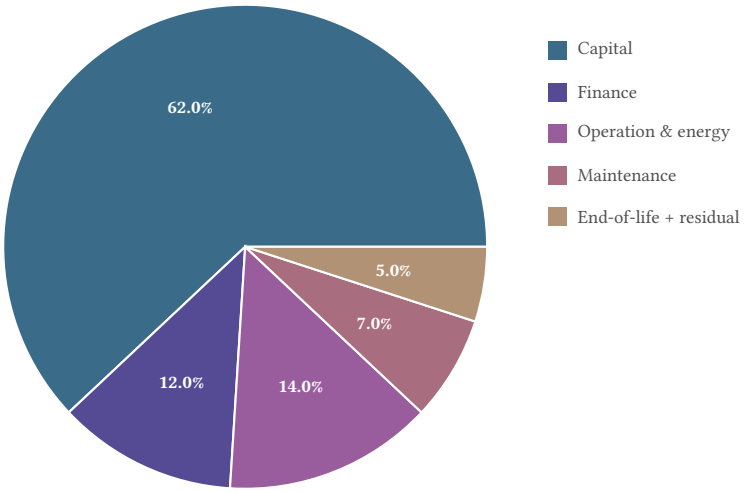


Figure 1: Figure 1 - Illustrative LCC composition for prefab steel over 25 years

3. Capital Cost Comparison

On pure material-plus-labour first cost, cast-in-place concrete is frequently 10-25% cheaper per square metre of structure in low-labour-cost markets. However, three adjustments close most of that gap: (1) steel structures require no formwork, which is a significant labour and material item in RC; (2) steel allows lighter foundations (typically 20-40% less foundation concrete on weak soils), reducing substructure cost; (3) in-labour-short or high-wage markets, the prefabricated shop environment yields higher productivity per employee-hour.

Cost item	Prefab steel (relative)	Cast-in-place RC (relative)	Note
Structure (material+labour)	1.00	0.80-0.90	RC cheaper in low-labour markets
Formwork	0.00	0.15-0.25	Major hidden RC item
Foundations	0.8-1.0 per tonne basis	1.0 baseline	Lighter steel frame reduces substructure
Site preliminary & temp works	0.05-0.10	0.15-0.30	Less site plant, fewer wet trades
Total erected structure	1.00	0.90-1.10	Gap narrows or reverses at higher clear spans

Table 1 - Capital cost comparison (indicative, normalised)

4. Schedule, Financing and Revenue Impact

Time is the largest unmodelled cost in most comparisons. Prefabricated steel is manufactured off-site in parallel with foundation works; on-site erection of a typical industrial building proceeds at 500-1,500 sqm of framed area per week. Published case benchmarks show steel-framed buildings reaching beneficial occupation 30-50% faster than comparable cast-in-place structures. That schedule gap compounds through: construction-period interest on the full project cost, earlier rental or production revenue, reduced preliminaries duration, and lower escalation exposure on a shorter tender-to-handover window.

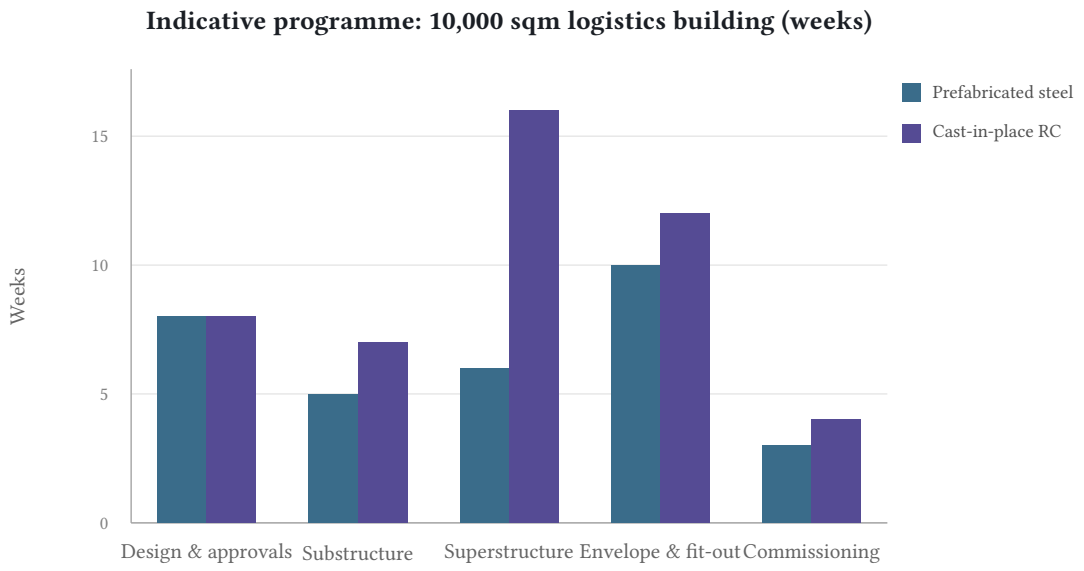


Figure 2: Figure 2 - Illustrative programme comparison

For a 10,000 sqm facility generating 12 USD/sqm/month net income, every month of schedule saving is worth roughly 120,000 USD of accelerated revenue - a single month often exceeds the entire capital-cost premium of steel in borderline cases.

5. Quality, Waste and Rework

Factory fabrication under EN 1090 or equivalent controlled environments reduces dimensional variability, weld quality risk and weather exposure relative to site-cast concrete. Measured rework and defect rates in published studies are typically 1-3% of contract value for prefabricated steel versus 3-8% for site-based reinforced concrete construction, with the gap widening in high-rainfall or extreme-heat regions. Material waste: steel scrap at fabrication averages 3-6% (and is fully recyclable with resale value); concrete formwork and over-pour losses routinely reach 5-10% with no recovery value.

6. Maintenance and Durability

Durability is design-dependent for both materials. Structural steel with hot-dip galvanizing to ISO 1461 and appropriate coating systems (ISO 12944 C2-C5) requires inspection painting on a 10-15 year cycle in benign environments. Unprotected or poorly detailed concrete requires attention at similar intervals: carbonation-induced cover loss, curing cracks and water ingress are the dominant RC maintenance drivers. In aggressive coastal or industrial atmospheres, both materials need engineered protection - the choice is a coating specification, not an inherent material advantage.

Durability factor	Prefab steel	Cast-in-place RC
Typical first major maintenance	10-15 yr (coating inspection)	10-20 yr (joints, cracks)
Corrosion strategy	Galvanizing + coating (ISO 1461/12944)	Cover depth + admixtures (EN 206)
Inspection ease	Visual, accessible members	Often hidden / requires probes
Extension & modification	Bolted connection changes, fast	Demolition or heavy retrofit, slow
Relocation potential	Dismantle and re-erectable	Not feasible

Table 2 - Maintenance and durability comparison

7. End-of-Life, Residual Value and Carbon

At end of life, steel structures are deconstructed and recycled at 90-98% recovery, and the recovered scrap has positive market value, which appears in the LCC as a residual credit. Cast-in-place concrete is typically crushed (constituting a disposal cost rather than revenue) or abandoned in place. On carbon: the manufacturing of steel is energy-intensive, but modern EAF and direct-reduction routes with high recycled content reduce that burden, and the full-cycle comparison - including concrete's process emissions (calcination) and demolition - shows both materials within a comparable range for typical buildings, with steel often gaining ground when reuse is considered.

Indicative cradle-to-gate embodied carbon (kg CO2e/sqm of structural frame)

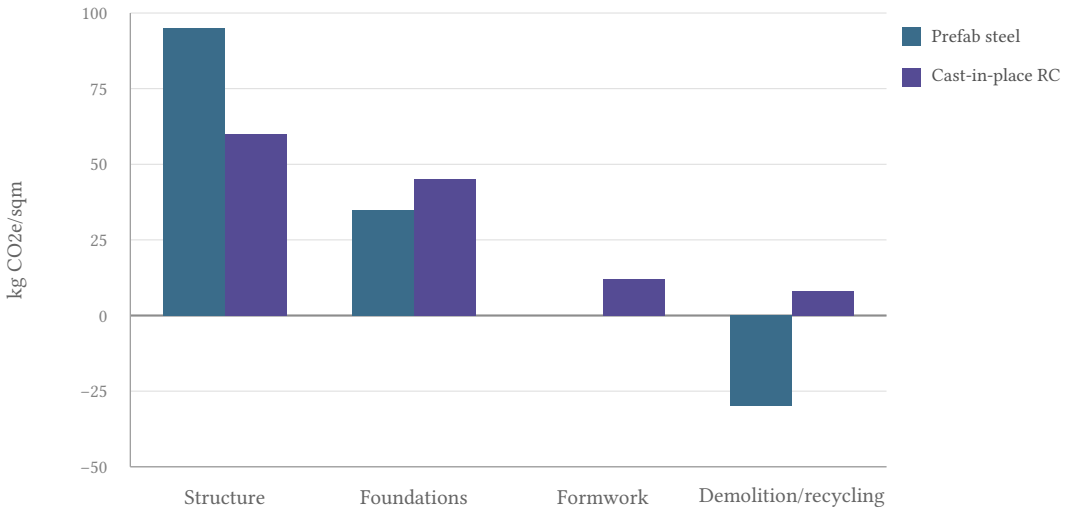


Figure 3: Figure 3 - Illustrative embodied carbon balance

8. Decision Framework

No single material wins every project. The framework below resolves most real-world selections. Choose prefabricated steel when: clear spans exceed 20-24 m; the programme is compressed or phased; soil conditions penalise heavy foundations; future extension or relocation is probable; site labour is

scarce or expensive; or the facility will change use within its life (logistics to cold storage, workshop to showroom). Choose cast-in-place concrete when: spans are modest, fire rating demands heavy member sizes anyway, local steel supply chains are unreliable, or the project is a monumental structure where mass and thermal inertia are design assets.

9. Worked Illustration - 10,000 sqm Logistics Warehouse

Metric	Prefab steel	Cast-in-place RC
Clear span of main bay	40 m (no intermediate columns)	12-15 m (column grid limited)
Structure capital cost (indexed)	100	95-108
Foundations	Bored piles, 18 m depth typical	Heavier pad + raft, 22-25 m typical
Programme to occupation	22-28 weeks	34-44 weeks
Accelerated revenue (12 USD/sqm/mo x 12 wks)	+360,000 USD	baseline
Expected residual credit (25 yr)	2-4% of capital (scrap value)	negative (disposal cost)
LCC 25-year total (indexed)	100	104-118

Table 3 - Worked illustration on a 10,000 sqm logistics building

> **The LCC advantage of steel concentrates in programme-sensitive and span-demanding projects. Run the framework with your own capital, inflation, interest and revenue assumptions before deciding - the model matters more than any single benchmark.**

10. Using This Framework with a Supplier

1. Request a structural LCC breakdown, not a per-tonne price, from steel suppliers.
2. Ask for reference delivery performance data (weeks to occupation) on projects comparable to yours.
3. Verify coating system and maintenance cycles against ISO 12944 based on your local atmosphere category.
4. Include foundation savings and schedule acceleration in your internal business case before capital approval.
5. Sensitise the model to your financing rate - at high rates, shorter programmes dominate all other factors.

11. References

References

[1] ISO 15686-5: Buildings and constructed assets - Service life planning - Life-cycle costing

[2] ISO 1461 / ISO 12944: Hot-dip galvanizing and protective paint systems

[3] EN 1090-2: Execution of steel structures - Technical requirements

[4] EN 206: Concrete - Specification, performance, production and conformity

[5] RS Means: Building Construction Cost Data, annual editions (capital cost benchmarks)

[6] Published LCC studies comparing steel and concrete frames (e.g., AISC / Tata Steel / SCI guidance documents)