

The
intelligent
construction
choice

Steligence®

6-Storey Residential Building Case Study:

Comparing Embodied
Carbon, Build Speed,
and Cost by
Structural System



ArcelorMittal



About Steligen®

Steligen® is a global initiative by ArcelorMittal using scientific evidence to show the benefits of steel design in building construction. Using a holistic analysis concept, competitive steel building solutions are identified.

It enables building owners, architects, and engineers to use a fact-based approach to evaluate construction options and collaborate on creating more sustainable and cost-effective buildings.

Smarter steels for people and planet

ArcelorMittal is one of the world's largest steel and mining companies. Guided by a philosophy to produce safe, sustainable steel, it is a leading supplier of quality steel products in all major markets including automotive, construction, energy, household appliances and packaging. ArcelorMittal is present in more than 60 countries and has an industrial footprint in more than 20 countries.

With a strong presence in North America, Europe, South America and South Africa, and an emerging presence in China, ArcelorMittal delivers a large scale of products, solutions and services to customers with the same quality focus in all regions. ArcelorMittal is a leader in steel technology, both in the breadth and depth of our product portfolio, and in our ability to supply a range of grades throughout the world. ArcelorMittal is a supplier of choice for all markets, a testament of our commitment to working collaboratively with our customers to engineer advanced steel grades to meet their needs.

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June 2026

Introduction

Residential mid-rise buildings are a popular choice for developers in today's urban centers. Combining the benefits of low and high-rise structures, mid-rise provides an answer for densification while maintaining street level comfort for pedestrians. Numerous concrete, steel and timber-based solutions exist with each lending their own unique set of advantages. To assess the environmental and financial impacts, ArcelorMittal has completed the following case study using the holistic guiding principles of Steligen®.

Project Partners

ArcelorMittal Dofasco partnered with several firms to develop the 6-storey case study.

Architectural Design

mcCallumSather

Cost and Construction Schedule Estimation

Hanscomb
QUANTITY SURVEYORS

Structural Engineering

wsp Blackwell

Panelized Steel Design Assist

MAGEST

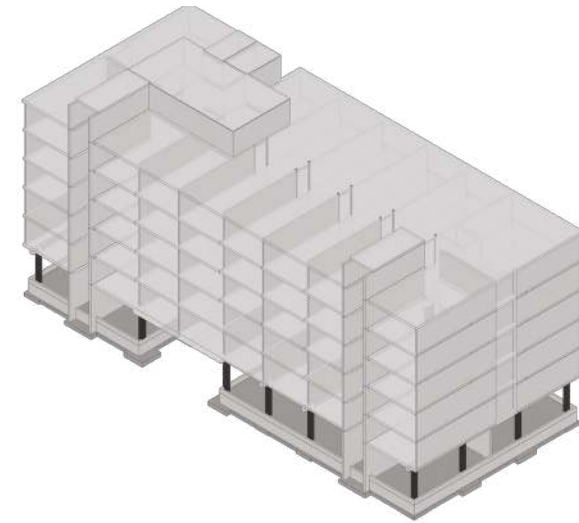
Third Party LCA Reviewer

ha/f



Building Overview & Functionality

The case study was designed as a 6-storey mixed-use commercial and residential building located in the Greater Toronto and Hamilton area. The design uses a split ground level podium for the commercial space separated by a pedestrian walkway, and residential units occupying the upper levels.



Size: 6,916m² Gross Construction Area

- Stacking: 6-storey
- Level 1 – Retail, building amenities
- Level 2-6 – Mix 1-2 Bedroom Units (75)
- Rooftop mechanical penthouse

Design Scenarios

Based on the 2024 Ontario Building Code, design scenarios were analyzed covering steel, concrete and timber construction. For the purposes of the study, only the structural elements of the core, upper levels and roof were significantly altered. The structural design of the stick frame steel building, and panelized steel frame building were the same, and so the results are only presented once in the below table.

	Steel (Stick Built LSF / Panelized LSF)	Cast-in-Place (CIP) Concrete	Precast Concrete	Mass Timber	Stick Frame Timber
Foundation	Spread footings, concrete slab-on-grade				
Level 1 Podium	Reinforced Cast in place concrete (CIP) wall, columns, slabs, beams				
Core, Shear Wall	CIP reinforced concrete	CIP reinforced concrete	Precast concrete	Cross-laminated timber	Softwood timber shear walls
Levels 2-6	Deep composite deck spanning between load bearing steel stud walls; localized steel lintels and HSS columns	One-way CIP Concrete slabs supported on CIP concrete walls; localized steel lintels	Hollow precast concrete floor slabs on precast walls	Glue-laminated Timber slabs supported on GLT beams/columns or CLT walls	Wood I-joists with plywood sheathing, supported on softwood timber beams or timber stud walls
Roof	Deep composite deck	CIP concrete slabs	Hollow precast concrete slabs	GLT slabs	Wood I-joist & plywood
Envelope	Steel stud with exterior insulation & Metal panel window wall glazing				
Interior Framing	Light steel framing (LSF)				Wood studs
MEP Systems	Standard mechanical, plumbing, electrical systems as per Ontario Building Code				
Interior Finishes	Modern residential floor, wall, ceiling finishes and fixtures				



Global Warming Potential Results

A whole building life-cycle assessment was conducted using OneClick LCA to assess the global warming potential of all design scenarios from cradle to grave, including all elements within the building. OneClick LCA is one of the most frequently used and cited tools for building life cycle analysis. The National Whole Building Life Cycle Assessment Practitioners Guide, published by the National Research Council (October 2024), was used as the basis for embodied carbon reporting. The scope of the LCA extended beyond the mandatory fields, and included optional scope items as well, such as interior finishes and doors.

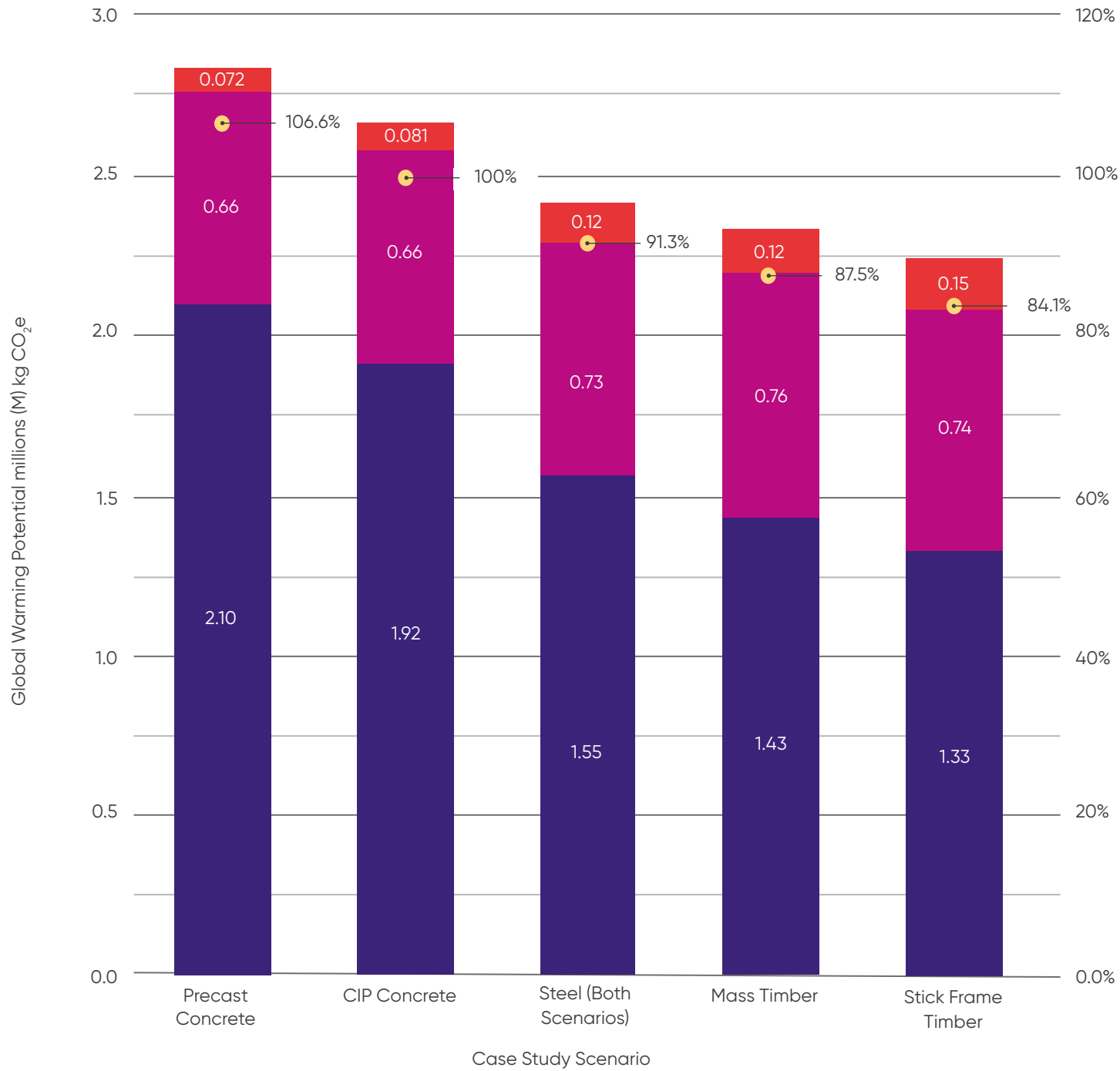
A bill of materials was generated using Revit Schedules from the architectural and structural models, from all three design scenarios. Environmental product declarations (EPDs) were selected following a local procurement strategy, initially considering products in the Greater Toronto Area (GTA), then expanding to Ontario, Canada, and globally. Product specific EPDs were selected whenever possible, in lieu of industry average. This analysis compares lower carbon material options in all three scenarios, as outlined in the table below. These lower carbon alternatives were held constant amongst all three building scenarios. For example, XCarb® steel studs were considered in the steel, concrete, and mass timber building scenarios.

Building Element	Lower Embodied Carbon Scenario
Footings	50% Slag + GUL cement
Concrete Walls	35% Slag + GUL cement
Concrete Columns	35% Slag + GUL cement
Concrete Slab-on-Grade	50% Slag + GUL cement
Concrete Beams/Slabs	35% Slag + GUL cement
Interior & Exterior Steel Studs	ArcelorMittal Dofasco XCarb® – Cold-formed sections
Steel Cladding	ArcelorMittal Dofasco XCarb® – Steel cladding & roofing
Furring & Resilient Channels	ArcelorMittal Dofasco XCarb® – Cold-formed sections

Combining the bill of materials and EPDs, the life-cycle assessment results are as follows. As the panelized steel scenario and stick built steel scenario have the same bill of materials, the LCA result is the same, and therefore, only reported once:

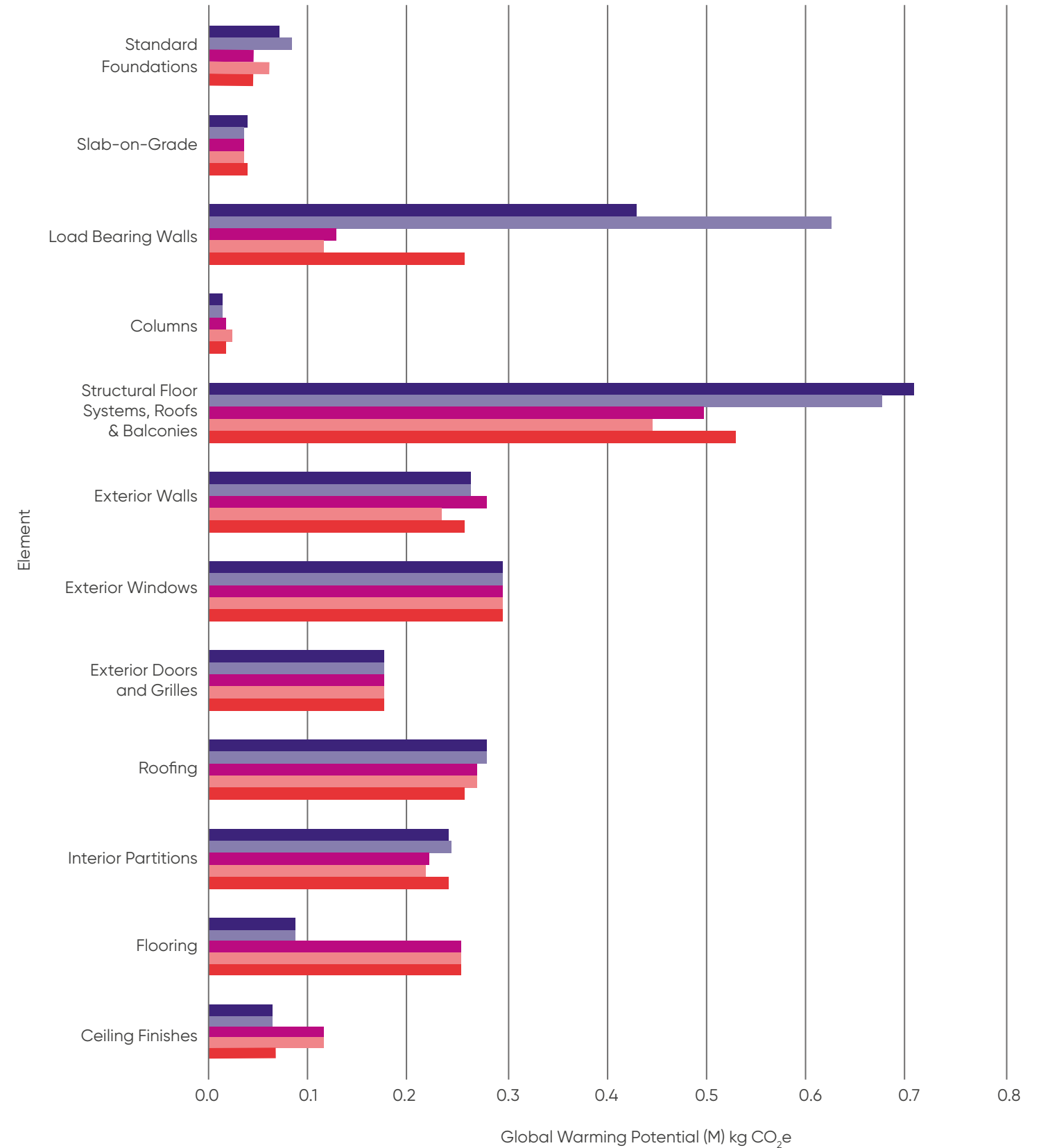
Whole Life Carbon Life Cycle Assessment (M) kg CO₂e

■ A1-A5 ■ B4-B5 ■ C1-C4 ● Percent



Life Cycle Carbon - Global Warming, (M) kg CO₂e Element Comparison

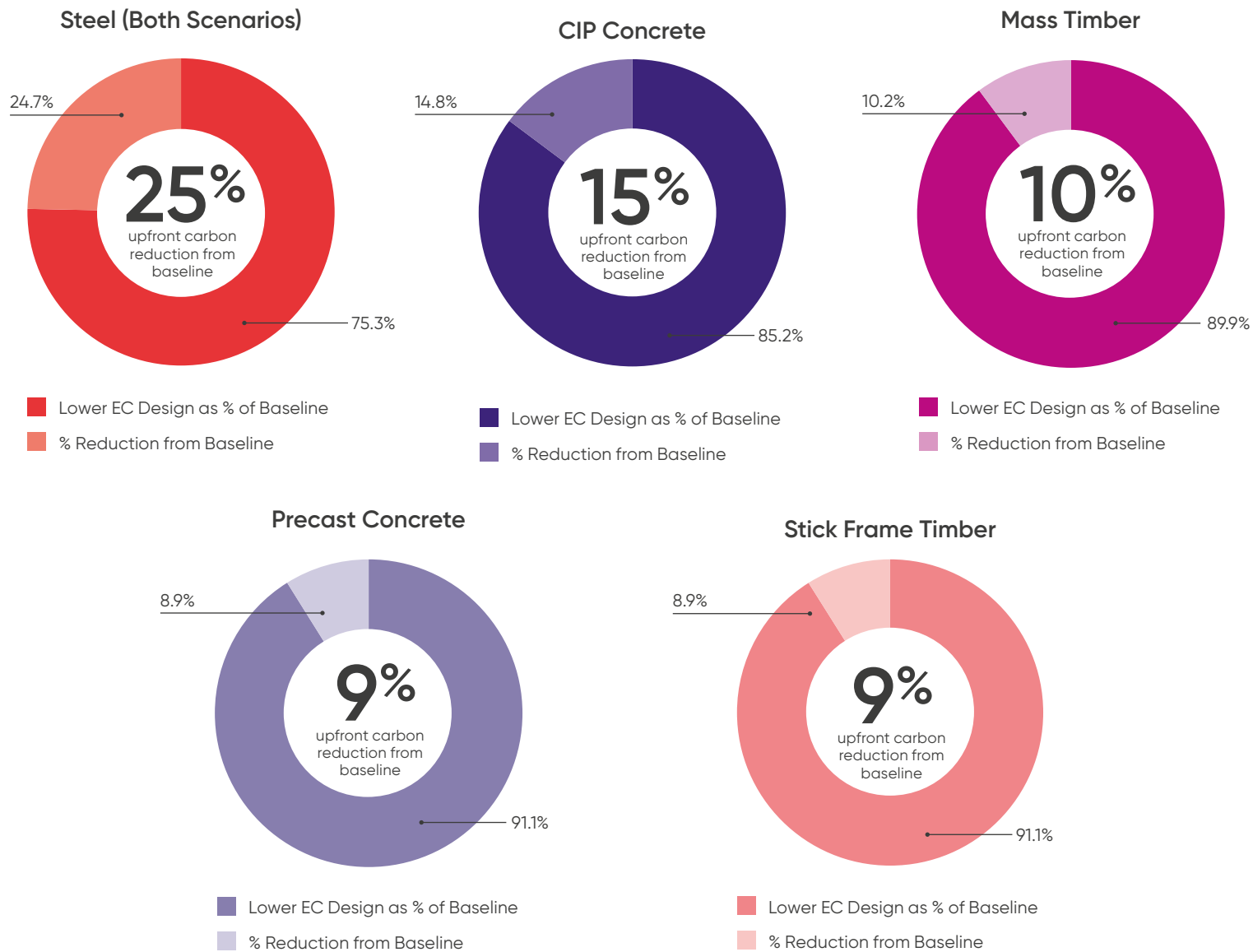
■ CIP Concrete ■ Precast Concrete ■ Mass Timber ■ Stick Frame Timber ■ Steel (Both Scenarios)



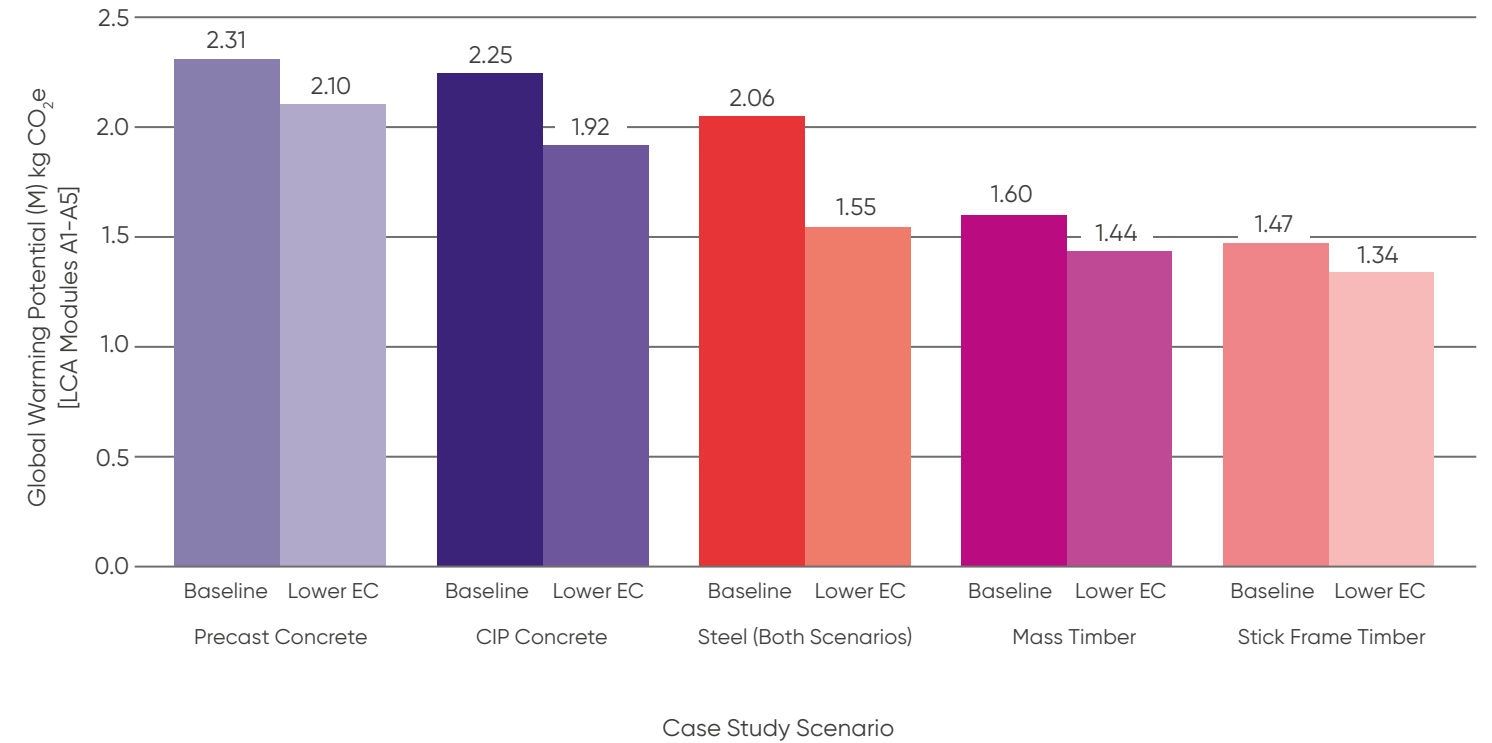
GWP results varied significantly across all of the scenarios examined. Investigating the differences in all scenarios at the elemental level yields the greatest insights into the benefits and challenges associated with each design. Much of the disparity in carbon is revealed in analyzing the vertical structure. Both the precast concrete and CIP concrete scenarios tie up a significant amount of carbon in the walls. By contrast, the mass timber and stick frame timber buildings require comparatively lower amounts of embodied carbon to produce these elements, with the steel scenarios landing in between. As all building scenarios have a CIP concrete podium, the difference in embodied carbon between scenarios is not as pronounced as may be expected. Although the transfer slab thickness and design deviates between scenarios, and is adjusted to suit the load, the tighter than expected spread speaks to how much carbon is consumed in transfer elements.

An analysis was also completed to determine the impact of utilizing the lower carbon materials. Using OneClick LCA, the assessment was re-run replacing the lower carbon alternatives for concrete and steel with the corresponding Concrete Ontario baseline or CSSBI industry average EPD. Lower carbon concrete and steel were found to reduce the upfront carbon from baseline by approximately 25% in the steel scenario, 9% in the precast concrete scenario, 15% in the CIP concrete scenario, 10% in the mass timber scenario and 9% in the stick frame timber scenario. This reiterates the significance of low carbon product selection. A visual breakdown of the contribution of each low-carbon element is provided in the pie charts below.

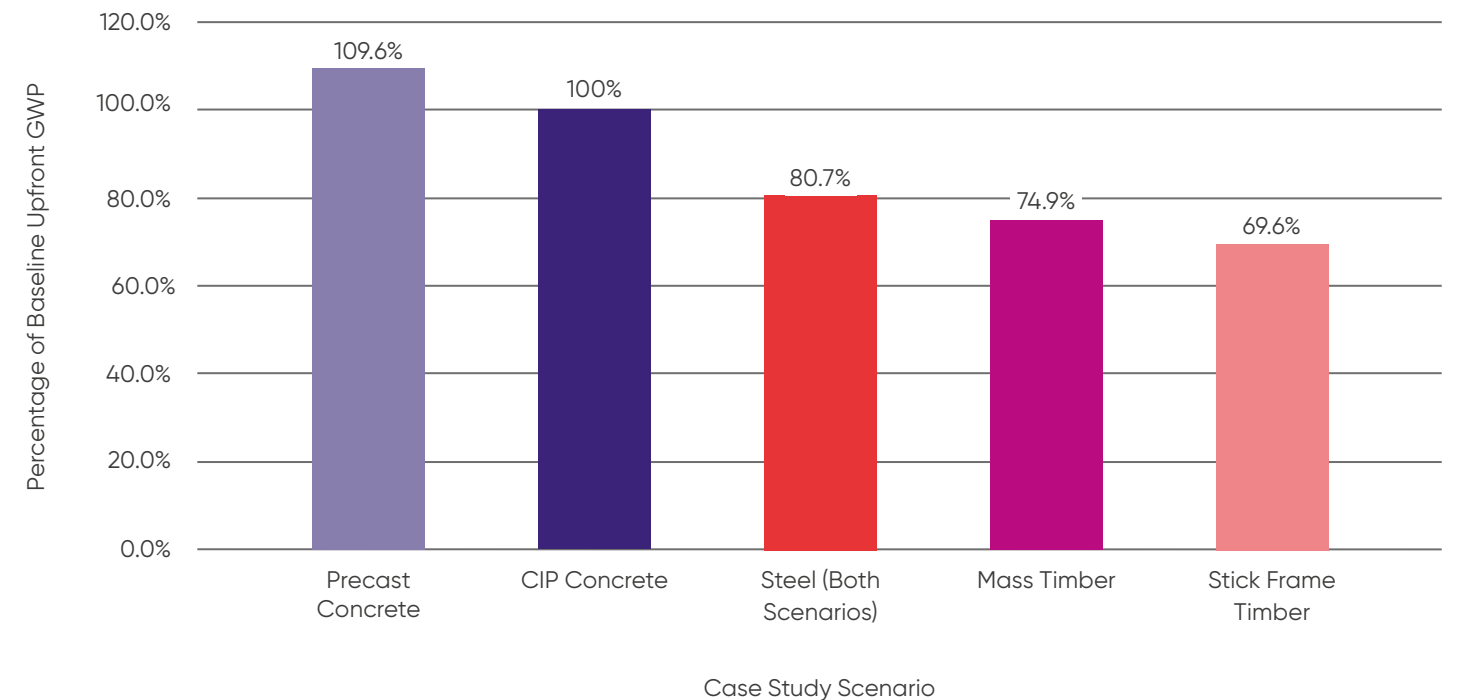
Material Contributions to Reduction From Baseline



Upfront Carbon (A1-A5) Reduction From Baseline



Upfront Carbon (A1-A5) Relative Comparison

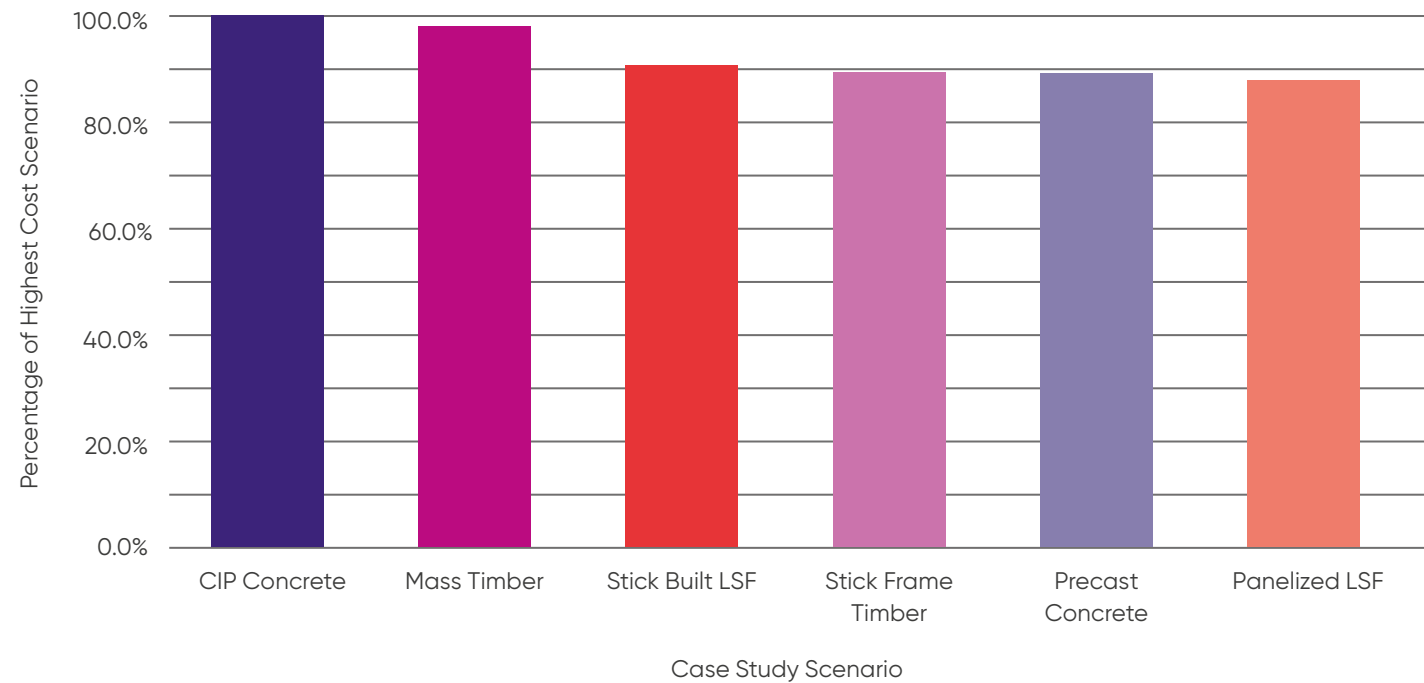


Financial Results

Hanscomb Limited provided a Class D cost estimate for all six scenarios studied. The cost estimation results are summarized in the table below. There was a 12% spread in cost between the most expensive system, cast-in-place concrete, and least expensive system, panelized LSF.

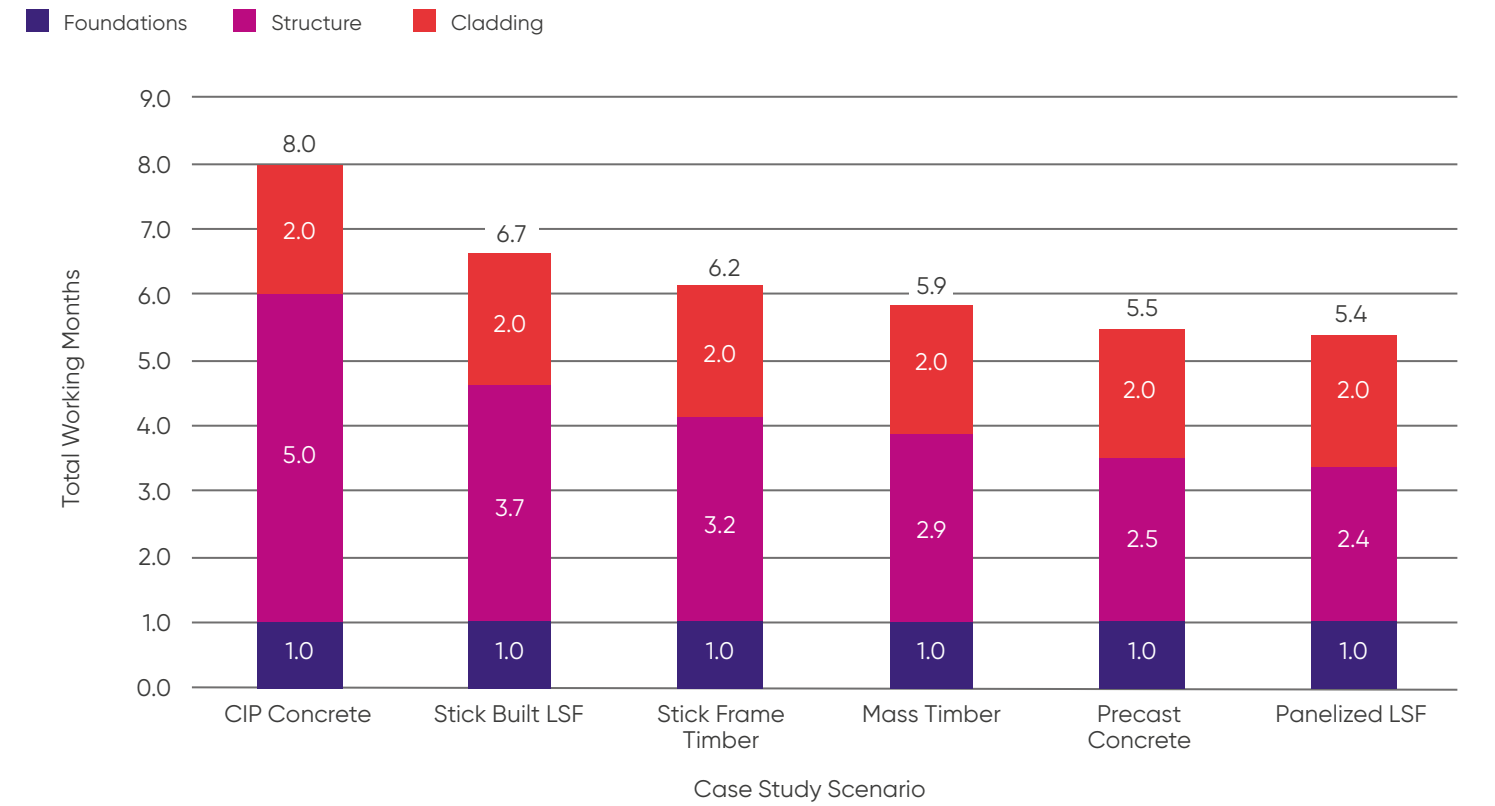
	CIP Concrete	Mass Timber	Stick Built LSF	Stick Frame Timber	Precast Concrete	Panelized LSF
A1 Substructure	\$734,200	\$659,300	\$647,700	\$680,800	\$764,900	\$734,200
A2 Structure	\$8,567,800	\$7,909,400	\$5,931,200	\$4,981,800	\$5,725,700	\$5,461,200
A3 Exterior Enclosure	\$4,289,800	\$4,310,000	\$4,279,900	\$4,207,900	\$4,251,300	\$3,883,800
B1 Partitions & Doors	\$1,823,600	\$1,984,400	\$2,082,100	\$2,780,900	\$1,823,600	\$2,146,400
B2 Finishes	\$2,723,400	\$2,723,400	\$2,723,400	\$2,723,400	\$2,723,400	\$2,723,400
B3 Fittings & Equipment	\$1,891,800	\$1,891,800	\$1,891,800	\$1,891,800	\$1,891,800	\$1,891,800
M&E & Site Work	\$7,186,200	\$7,186,200	\$7,186,200	\$7,151,200	\$7,186,200	\$7,186,200
Z1 General Requirements	\$4,180,500	\$4,095,600	\$3,800,400	\$3,750,500	\$3,742,700	\$3,690,500
Design & Pricing Allowance	\$3,139,730	\$3,076,010	\$2,854,270	\$2,816,830	\$2,810,960	\$2,771,750
Total	\$34,537,030	\$33,836,110	\$31,396,970	\$30,985,130	\$30,920,560	\$30,489,250

Relative Cost Comparison



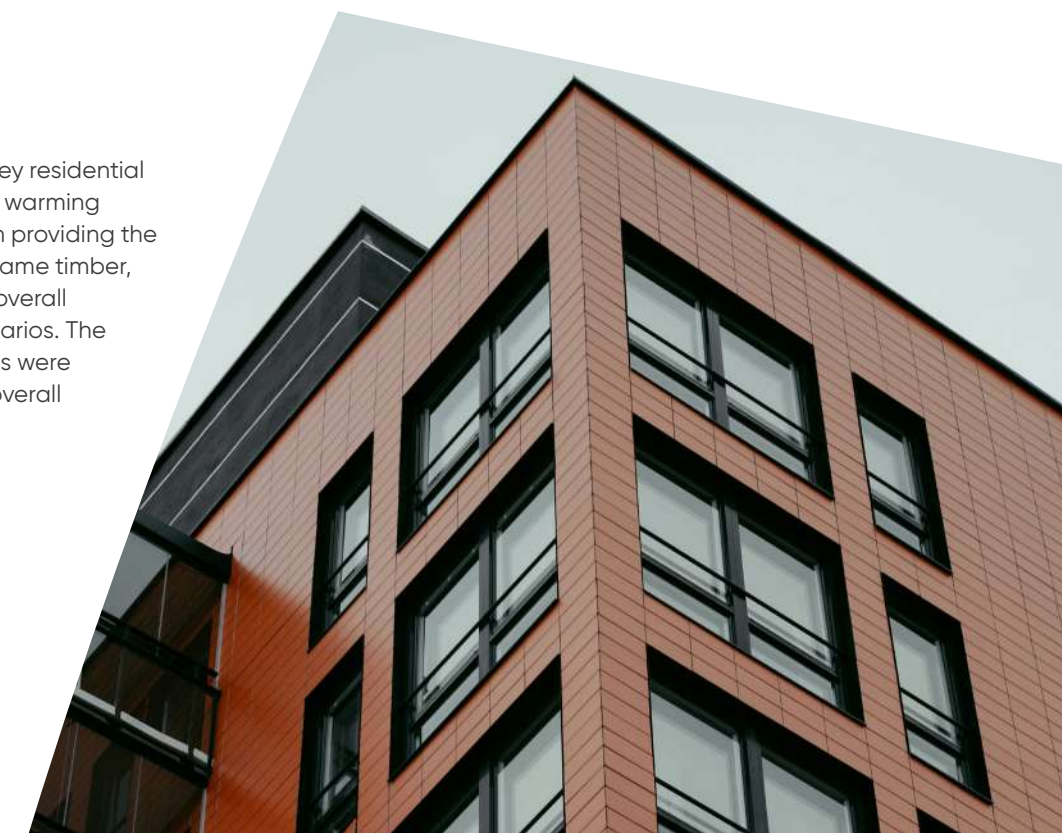
Construction Schedule

The construction schedule was estimated by Hanscomb Limited. In general, the structural systems considered more prefabricated in nature resulted in the fastest construction schedule. Conversely, systems requiring additional labour on site for assembly or installation had a comparatively slower schedule.



Conclusion

In this Steligence® case study, the six 6-storey residential designs differed quite significantly in global warming potential, with the stick frame timber design providing the lowest GWP. The LSF based designs, stick frame timber, and precast concrete were comparable in overall construction cost versus the other two scenarios. The panelized LSF and precast concrete designs were estimated to be the fastest to erect in the overall construction schedule.



XCarb[®]

Towards net zero steel

XCarb[®] is ArcelorMittal's 'towards net zero steel' transformation programme. It brings together all of the company's reduced, low and zero-carbon steel products, processes and technologies, innovation projects, initiatives and alliances in one single-minded effort to make the changes needed to get our organisation and our industry to carbon neutrality by 2050.

ArcelorMittal's objective is to be the steel company of the future. XCarb[®] will play a key role in that.

Smarter steels for people and planet



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