The intelligent construction choice

Steligence®

12-Storey Residential Building Case Study:

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

ArcelorMittal

About Steligence®

Steligence® 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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Introduction

Major cities and the surrounding regions continue to be drivers of both local and national economies today. As economies steadily expand and job demand grows, there is a pressing need to increase the affordable housing supply for the population, through densification in high-rise buildings while limiting urban sprawl.

Project Partners

ArcelorMittal Dofasco Global R&D partnered with several firms to develop the 12-storey case study.

Architectural Design

mcCallumSather

Cost and Construction Schedule Estimation

Hanscomb QUANTITY SURVEYORS

Structural Engineering

MTE WSP rjc Engineers

Third Party LCA Verification

MANTLE —CLIMATE—

Building Overview & Functionality

The case study was designed as a 12-storey residential building for a corner site overlooking two streets located within the Greater Toronto and Hamilton area.

Size: 26,655 m² Gross Floor Area

Stacking: 12-storey

- Basement – 1 level underground parking
- Level 1 – main entrance, amenities, services/utilities, access to parking
- Unit Types: 1BR, 2BR
- Levels 2-12 – residential,
- 19 units per floor
- Rooftop mechanical penthouse

Design Scenarios

Three unique building scenarios were analyzed comparing steel-, concrete- and mass-timber-based designs. For the purposes of the study, only the structural elements were significantly altered in each scenario.

	Steel	Concrete	Mass Timber
Foundation & Underground Parking	Strip/spread footings, slab-on-grade		
Lower Floors (1 & 2)	Cast-in-place (CIP) concrete slabs and columns		
Upper Floors & Balconies	Deep composite deck, precast concrete slab balconies	Two-way CIP slabs	Point supported Cross-laminated Timber slabs
Vertical Structure	Hollow Structural Sections, LSF walls	CIP Concrete columns	Glue-laminated Timber columns
Beams	Wide-flange sections, built-up steel stud sections	CIP Concrete	Glue-laminated Timber & Steel wide flange sections
Core, Shear, Load Bearing Walls	CIP Concrete	CIP Concrete	CIP Concrete
Envelope	Steel stud with exterior insulation & Metal panel window wall glazing		
Roof	Deep composite deck	CIP Concrete	Cross-laminated Timber
Interior Framing	Light steel framing (LSF)		
MEP Systems	Standard mechanical, plumbing, electrical systems as per Ontario Building Code		
Interior Finishes	Modern residential floor, wall, ceiling finishes and fixtures *Mass timber encapsulation based on 2-hr fire rating requirement		

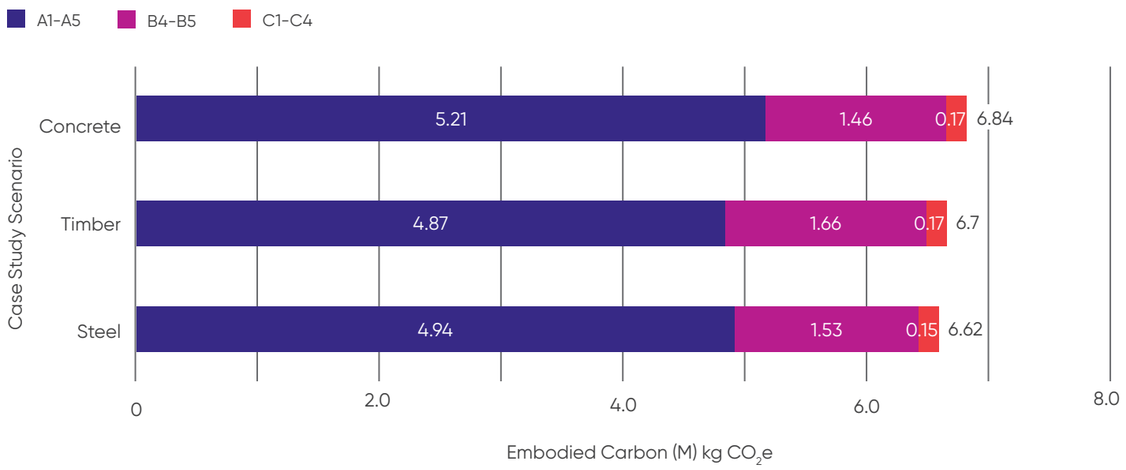
Global Warming Potential Results

A whole building life-cycle assessment was conducted using OneClick LCA to assess the global warming potential of the three 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.

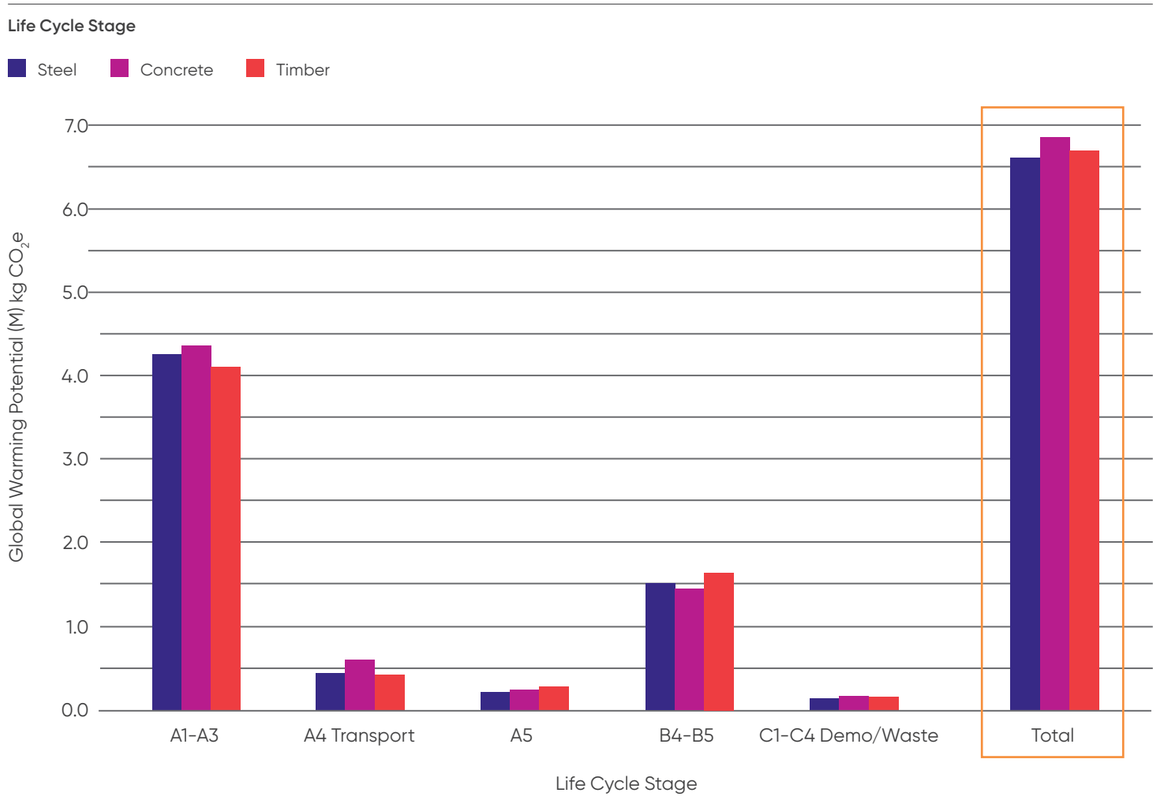
A bill of materials was generated using Revit Schedules from the architectural and structural models, from all three design scenarios. Environmental product declarations (EPDs) were selected following a local procurement strategy, initially considering products in the Greater Toronto Area (GTA), then 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
Mass Timber	Glulam (British Columbia); CLT (Ontario)

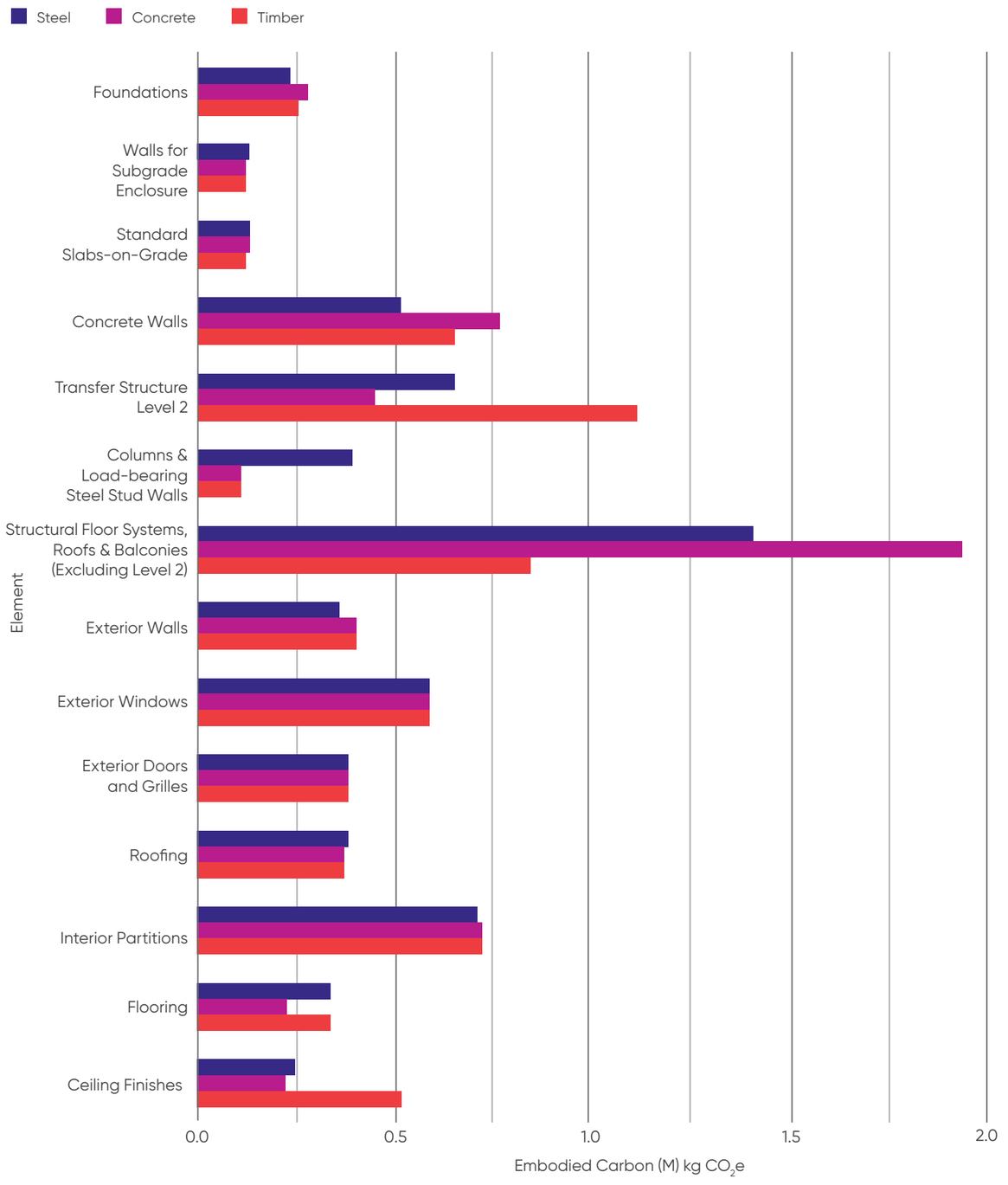
Global Warming Potential



Life Cycle Stage



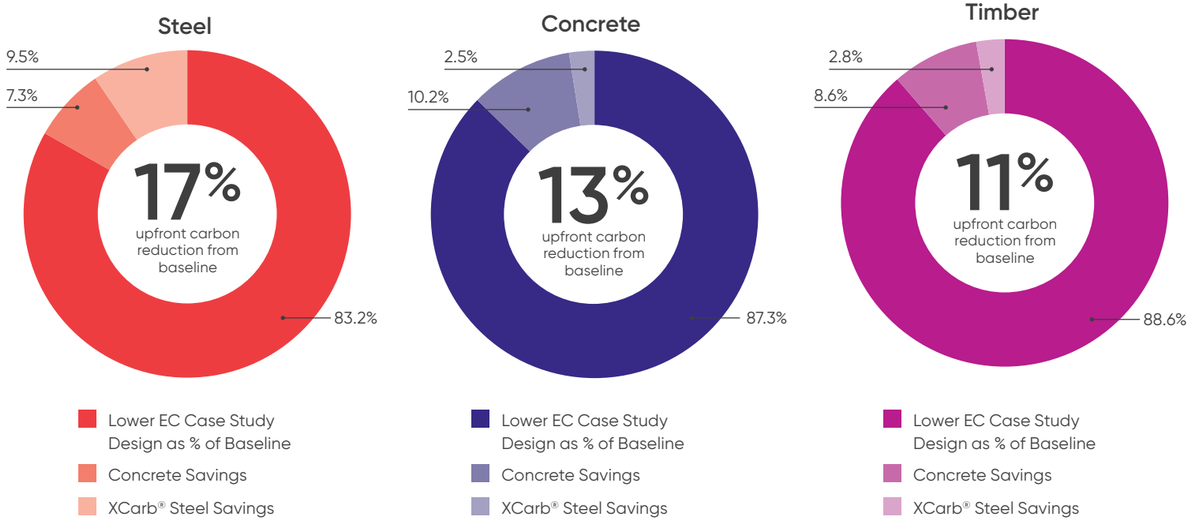
Life Cycle Carbon - Global Warming Potential (M) kg CO_2e Element Comparison



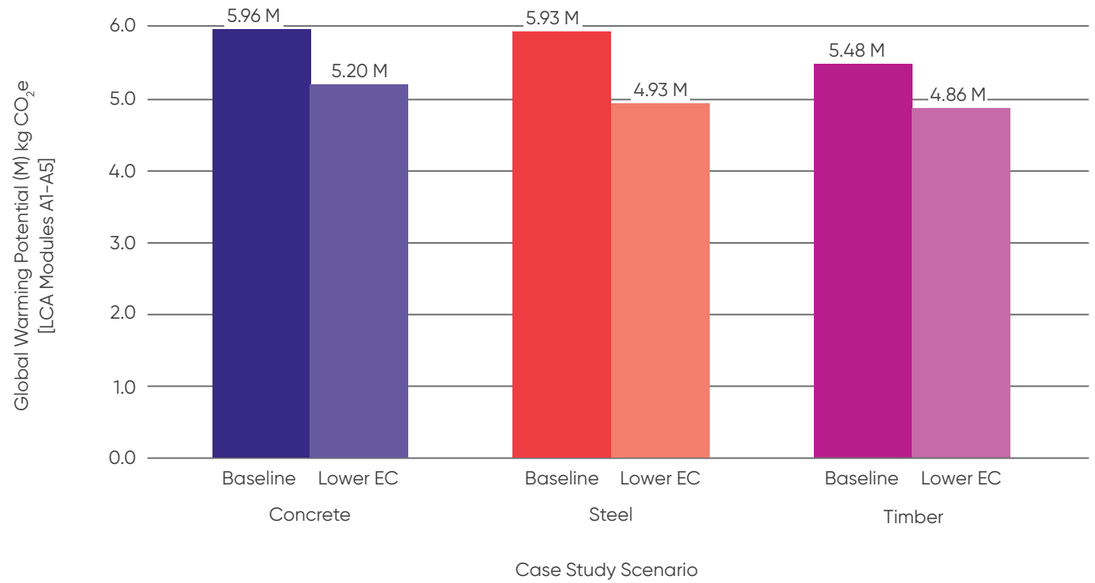
GWP results were comparable across the three scenarios examined with the bulk of the embodied carbon (EC) generated from the A1-A3 modules. Investigating the differences in the three scenarios at the elemental level yields the greatest insights into the benefits and challenges associated with each scenario. Relative to the concrete baseline, the steel building scenario sees the greatest reduction from baseline in the horizontal structure, primarily attributed to the composite deck system. Conversely, the steel building ties up more carbon in the vertical structure, with more robust steel stud walls. Similarly, the mass timber framed building also sees significant reductions from the baseline concrete scenario in the horizontal structure above Level 2. However, due to the increased number of columns with the mass timber design, the transfer slab is required to be significantly more robust.

Given the relatively tight spread between the three scenarios, an analysis was 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 17% in the steel scenario, 13% in the concrete scenario, and 11% in the 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

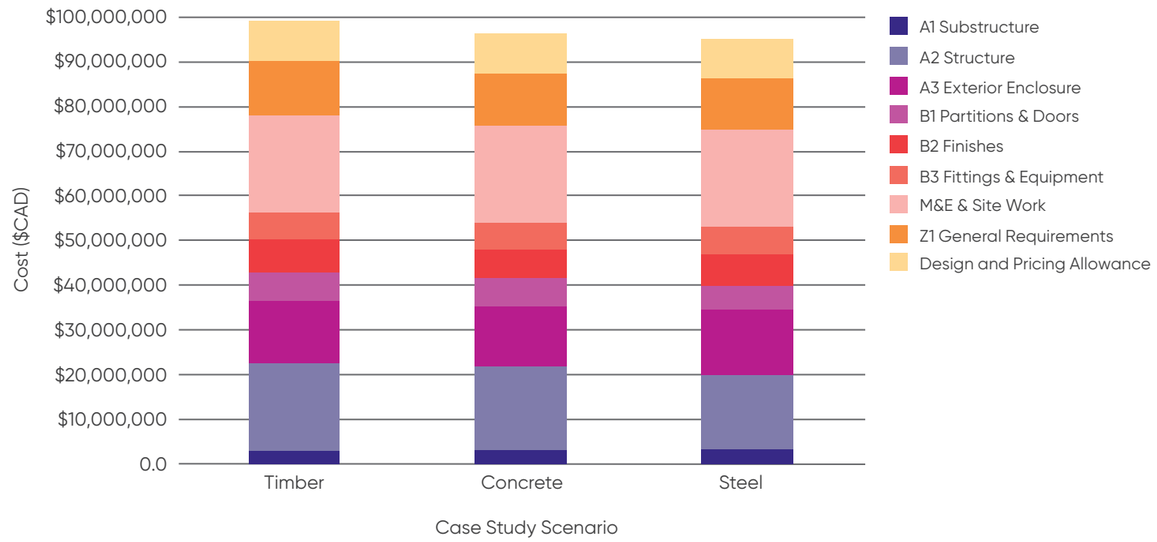


Upfront Carbon (A1-A5) Reduction From Baseline



Financial Results

Hanscomb provided a detailed class D cost estimate for all three scenarios studied. Overall, all three scenarios were comparable in total cost with the steel scenario having a slight advantage.

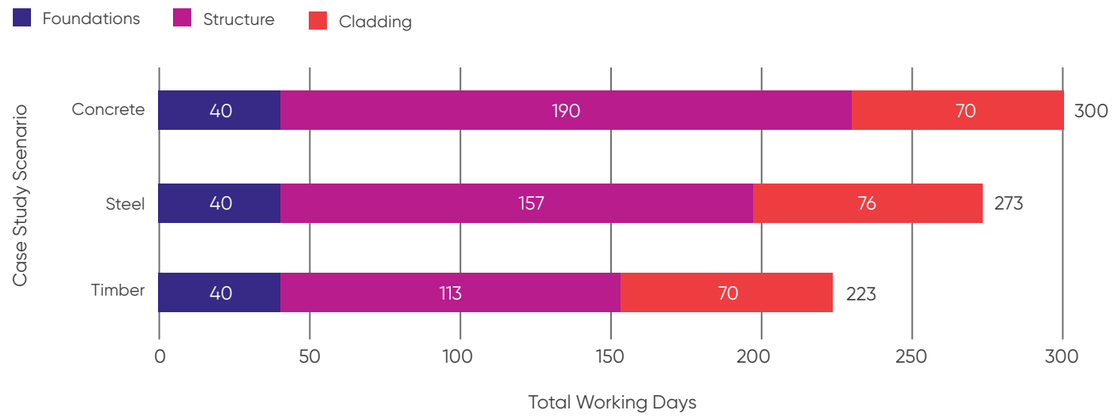


Major categorical cost differences between the three scenarios are outlined below.

	Steel	Concrete	Timber
A1 Substructure	$3,107,500	$3,121,500	$3,011,000
A2 Structure	$16,822,500	$18,706,600	$19,489,000
A3 Exterior Enclosure	$14,649,500	$13,520,000	$14,011,300
B1 Partitions & Doors	$5,366,900	$6,287,000	$6,263,000
B2 Finishes	$7,040,500	$6,385,400	$7,546,300
B3 Fittings & Equipment	$6,039,700	$5,955,500	$5,955,500
M&E and Site Work	$21,805,300	$21,805,300	$21,805,300
Z1 General Requirements	$11,494,200	$11,640,100	$11,993,300
Design & Pricing Allowance	$8,632,610	$8,742,140	$9,007,470
Total	**$94,958,710**	**$96,163,540**	**$99,082,170**

Construction Schedule

The schedule was developed by Hanscomb. Timber was observed to have shortest construction schedule while the concrete building scenario had the longest schedule.



Conclusion

In this Steligence® case study, the three 12-storey residential designs were comparable in global warming potential. The steel-based design had a slight advantage in overall construction cost versus the other two scenarios and the timber-based design was 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.

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