The intelligent construction choice

Steligence®

22-Storey High-Rise Residential Building Case Study

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 allows building owners, architects, and engineers a fact based approach to view building construction, for collaboration to build sustainable, more cost-effective buildings.

Smarter steels for people and planet

ArcelorMittal is the world's leading steel and mining company. Guided by a philosophy to produce safe, sustainable steel, it is the 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 the 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.

ArcelorMittal Dofasco

Box 2460, 1330 Burlington Street East
Hamilton, ON L8N 3J5 Canada
dofasco.arcelormittal.com

@ArcelorMittal_D
facebook.com/arcelormittaldofasco
@arcelormittal_dofasco

+1 800 816 6333
customer-inquiries.dofasco@arcelormittal.com

ArcelorMittal North America

833 West Lincoln Highway
Schererville, Indiana 46375 USA
northamerica.arcelormittal.com

@ArcelorMittalUS
facebook.com/ArcelorMittalUSA

+1 800 422 9422
NorthAmericaSolutions@arcelormittal.com

Updated: July 2022

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.

Concrete has long been a staple in the development of multi-storey buildings. The latest advancements in structural & cold formed steel grades with innovative member design, have enabled steel to now be used as an alternative in many aspects of building construction.

ArcelorMittal has completed two high-rise case studies which incorporate affordable and efficient design layouts for both 12 and 22-storey residential buildings. Using the holistic guiding principles of Steligence®, this pair of studies quantifies the environmental and financial impacts between concrete and steel-based designs.

Building Overview & Functionality

The case study was designed as a 22-storey residential building for a corner site overlooking two streets located within the Greater Toronto and Hamilton area.

Size: 41,081 m² Gross Floor Area (442,192 ft²)

Stacking: 22-storey

Basement – 2 levels underground parking

Ground floor – main entrance, amenities, services / utilities, access to parking

Unit Types: 1BR, 2BR, 3BR

Levels 2-12 – residential, 18 units per floor

Levels 13-22 – residential, 9 units per floor

Rooftop mechanical penthouse

Design Scenarios

Two unique building scenarios were analyzed comparing a steel-based design with concrete. For the purposes of the study, only the structural elements were significantly altered in each scenario. Both buildings were independently designed by a professional architect and two engineering firms who managed the steel and concrete structural designs.

The columns of the steel design featured ArcelorMittal HISTAR® 460 structural sections. The innovative high strength low alloy design, contributed to both a lighter structure and reduced material cost over grades of lesser strength. Additional product information can be found online at the ArcelorMittal Europe Construction website.

	Steel	Concrete
Foundation	Cast-in-place (CIP) concrete columns, slabs	
Floors (all levels, including underground parkade)	Composite Steel Joist System	CIP concrete
Columns	AM HiStar® 460 sections	CIP concrete
Beams	Wide Flange Sections	CIP concrete
Interior Walls	Light steel framing	
Core, Shear, Load Bearing Walls	HSS chevron bracing, structural steel	CIP concrete
Exterior	Insulated steel stud wall, metal panel, window wall glazing	
Roof	Steel deck	CIP concrete

Environmental Results

The Tally® plug-in for Autodesk Revit was used to assess the environmental impact of the two design scenarios from cradle to grave for the entire building. Tally® is one of the most frequently used and cited tools for building life cycle analysis. Combining the bill of materials, and North American environmental product declarations (EPDs) from GaBi life cycle inventory, the following impacts were assessed for the lifespan (60 years) of each structure:

- Global warming (Embodied carbon, kg CO_2)
- Acidification (Acid rain, kg SO_2)
- Eutrophication (Nitrate eqv., kg N)
- Smog formation (NO_x, VOCs, O_3)
- Non-renewable energy (MJ)

Steel construction had GWP reduction of

20%

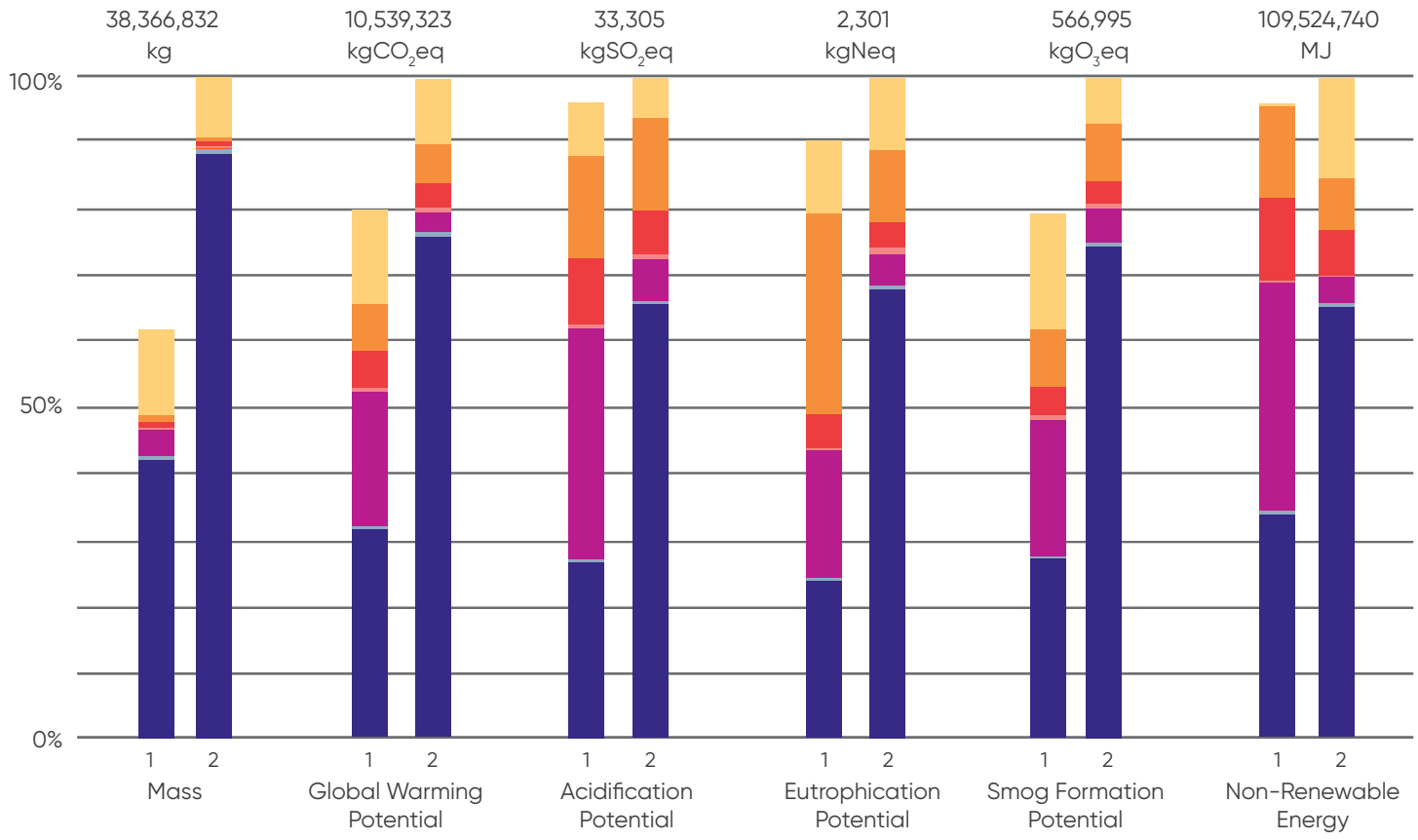
In terms of total values, the Tally® life cycle analysis showed the steel-based design had lower values across all five environmental impact indicators. A 20% reduction in Global Warming Potential (GWP) was observed in the steel-based design compared to the concrete-based design. This is equivalent to taking 422 vehicles off the road to save an annual emission of 2.1M kg CO_2. This is primarily attributed to the steel-based design weighing 38% less. The concrete used in both designs was the largest material contributor across the five environmental impact indicators.

Steel building was 38% lighter

Divisions

- 03 - Concrete
- 04 - Masonry
- 05 - Metals
- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes

Tally® LCA Results



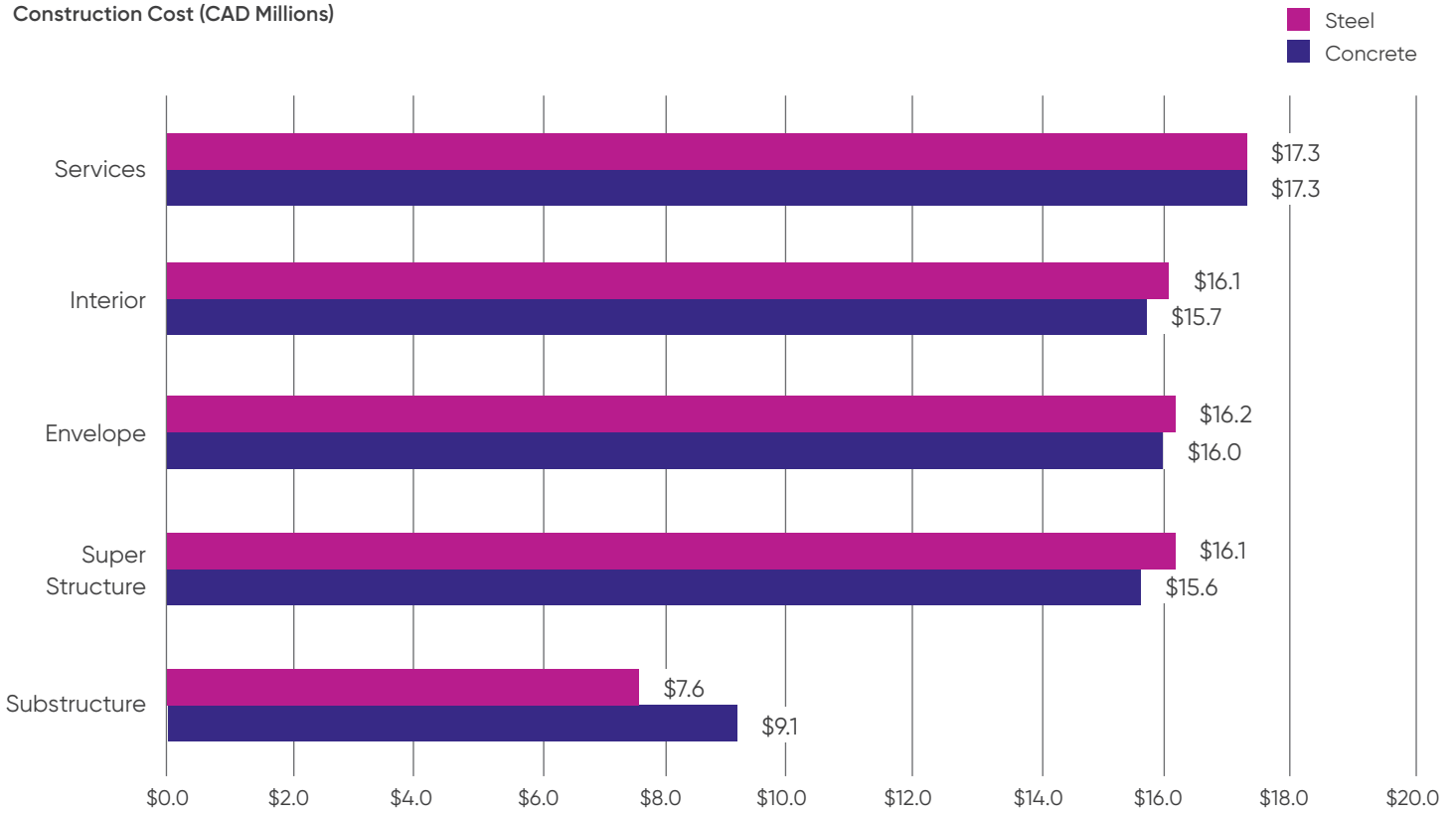
Design Options: Option 1 - Steel Option 2 - Concrete

Financial Results

Altus Group provided a full detailed cost estimate* based on a comprehensive structural design for the concrete and steel-based designs. The steel-based design had a $0.4M overall savings compared to the $73.7M net construction cost for the concrete-based design.

Overall savings of

$0.4M



*Class D Indicative Estimate

Construction Schedule

Construction schedule estimate was produced by MPA Project Consulting. The steel-based design had the shorter schedule, **completing construction 25 working days (5 weeks) prior to concrete**. This was primarily due to compression of floor construction time as the structure is built. The steel-based design begins at 7 days per floor for levels 3 to 6 and ends at 3 days per floor on levels 19 to 22 while the concrete-based design requires 8 days per floor for levels 3 through 13 and 5 days per floor for levels 14 through 22. The steel-based design efficiencies compound in high-rise and result in not only the one month of earlier occupancy, but less associated project costs such as equipment rental, trade services and financing & insurance costs.

	Steel	Concrete
Structure	225	275
Façade	294	315
Overlap	-88	-132
Structure + Facade	431	458
Building Overall	616	641

Steel building is completed ahead of concrete by 5 weeks

Rental Benefit for Owners (Sample Calculation)

Assumptions:

- Steel building can be occupied 5 weeks earlier, therefore at least 1-month of additional rent may be collected from tenants
- All residential units are being used as rental and are occupied at time of completion

Project Total Saleable Area (Residential): 187,813 ft^2
Average Rent Per Square Foot (Select New Condo Projects Toronto, ON*): $3.83 CAD
1-month of Rent for Owner: $719,324

*Source: Rentals.ca December 2021 Rent Report

Combined cost & schedule savings for the steel building

$1.1M

Conclusion

In this Steligence® case study, the steel-based design was found to have a $0.4M in construction cost savings, a 5-week schedule advantage, and a significantly lower environmental impact. A 20% reduction in GWP for the building was possible with steel, the equivalent of removing 422 vehicles off the road in terms of annual CO_2 emissions.

Together these environmental and financial benefits present a strong case for designing with steel in the high-rise residential market, and reinforce the findings found in the Office, Mid-rise and Passive House Steligence® case studies.

XCarb™

Towards carbon neutral steel

XCarb™ is ArcelorMittal's 'towards carbon neutral 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

ArcelorMittal