Passive House Net Zero Energy Ready Case Study

One of the biggest challenges the world faces today is how to address and minimize climate change resulting from carbon and greenhouse gas emissions. Buildings constructed using conventional methods have and continue to consume significant quantities of energy for heating and cooling, producing greenhouse gases in the process. The building industry and government bodies have recognized this problem and are in the process of updating the Canadian national building energy codes to achieve net zero ready buildings for 2030. The Passive House Institute has developed a set of standards for buildings specific to energy consumption, airtightness, interior temperature variation that will help guide buildings of the future in achieving this goal. Using Steligence® principles and methodology, ArcelorMittal has completed this Passive House/Net Zero Energy Ready case study on a mid-rise residential building, examining how steel, concrete and timber solutions compare environmentally and financially.

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: 6,916m^2 Gross Construction Area
- Functionality: mixed-use, commercial and residential
- Location: Greater Toronto & Hamilton Area
- Stacking: 6-storey

  Level 1 – Retail, building amenities

  Level 2-6 - Mix 1-2 Bedroom Units (75)
- Rooftop mechanical penthouse
- Design: Split ground-level podium with pedestrian walkway

	Steel	Concrete	Timber
Foundation	Insulated slab-on-grade		
Level 1 Podium	Cast-in-place (CIP) concrete transfer slabs, beams, walls, columns		
Mechanical, Electrical, Plumbing	Central energy recovery system, high efficiency mechanical systems		
Glazing	Triple-glazed curtainwall & windows		
Exterior Walls	Insulated steel stud, masonry, Indaten™ cladding	Insulated CMU, masonry, Indaten™ cladding	Insulated double wood stud, masonry, Indaten™ cladding
Core, Shear Wall	CIP concrete	CIP concrete	Cross laminated timber (CLT)
Levels 2-6	Composite deck, steel load bearing walls, light HSS columns and W beams across hallways	CIP concrete walls, columns, floor slabs	Glue laminated timber (GLT) floor slabs, beams, columns, CLT load bearing
Roof	Steel deck	Precast concrete	CLT slabs

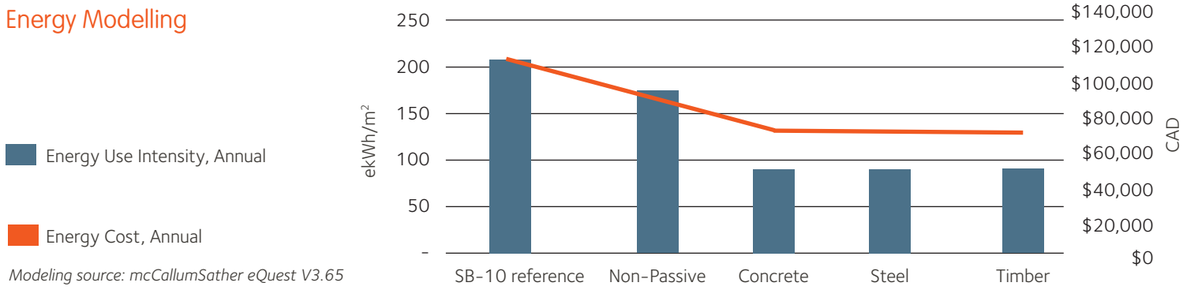
Passive Design Scenarios

Three different design scenarios were analyzed covering steel, concrete and timber construction. Each scenario incorporated a unique structural and exterior wall system designed to achieve the Passive House energy standard. All designs featured the same structural design for the first level with these additional upgrades:

- Insulated slab and footings
- Triple-glazed curtainwall, windows
- Increased roof insulation
- Centralized energy recovery system
- Thermally broken floor assemblies and balcony connections

By incorporating passive design elements, annual energy consumption was reduced by 55% compared to the Ontario Building Code SB-10 reference and 50% relative to a similar non-passive building in all three cases. The reduction lowered the utility costs by one third or $40,000 per year assuming an electrical and natural gas rate of $0.125/kWh and $0.09/m^3 respectively. Comparing energy performance of the designs, steel was able to achieve the same result as concrete and timber despite differences in the wall assembly and thermal properties.

Energy Modelling

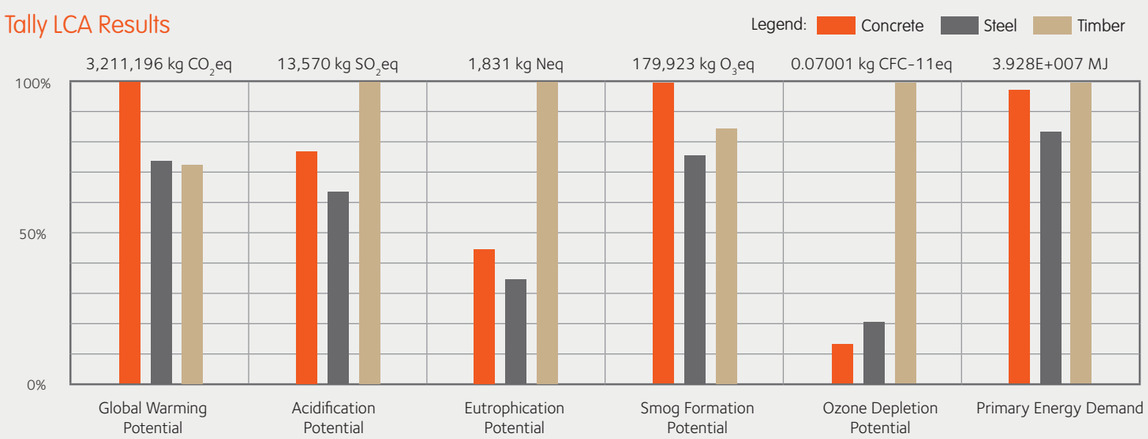


Modeling source: mcCallumSather eQuest V3.65

Environmental Results

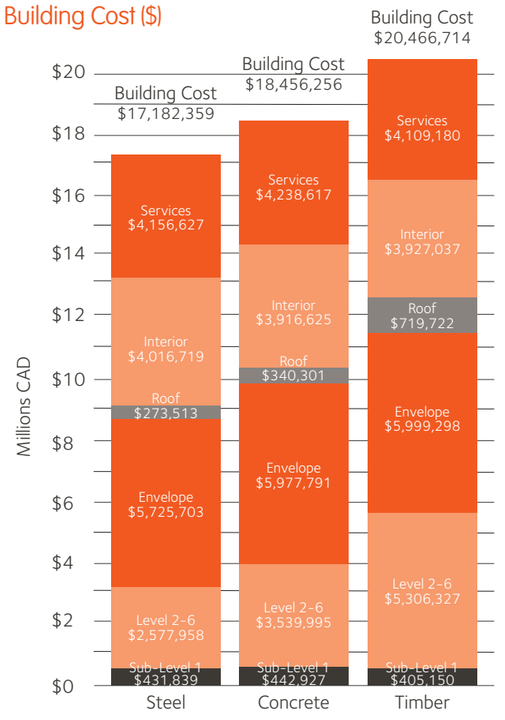
To assess the environmental impact of the design scenarios, a cradle-to-grave life cycle analysis (LCA) was conducted using the Tally® plug-in for Autodesk Revit. The LCA measures and compares the environmental potential for global warming, acidification, eutrophication, ozone depletion, and primary energy demand for the entire building over a 60-year lifespan.

Tally LCA Results



Results from the Tally LCA determined the steel-based design outperformed concrete and timber in a majority of the categories. Steel had the lowest potential for acidification, eutrophication, smog formation and energy demand. For global warming, steel and timber were similar, and both were significantly lower than concrete in CO_2 equivalent emissions. For ozone depletion potential, it should be noted that quantities of this scale are considered insignificant for all three designs, attributed to CFC emission restrictions. In summary, the LCA validated that steel-based construction solutions have the smallest environmental footprint in this passive house/net zero ready case study.

Building Cost ($)



Financial Source: Preliminary Construction Cost Estimate by Altus Group

Financial Results

Construction cost estimates were obtained for the three design scenarios from Altus Group. In terms of total cost, the steel design was the most economical at $17.2M CAD. The concrete estimate was 7% higher than steel, while mass timber was significantly higher at 19%. The difference was attributed to the increased material and installation costs of the concrete and mass timber in the upper floors and roof.

Conclusion

In this Steligence case study, the steel-based design was found to be the most environmentally sustainable and economical compared with concrete and timber alternatives.

As the construction industry continues to move towards net zero energy ready buildings, steel provides both a viable and favorable solution. It can achieve the energy requirement as defined in the Passive House standard, while maintaining the lowest environmental impact and cost of ownership.

What is 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.

Why Steligence®?

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

About ArcelorMittal

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

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

October 2020