rediscover CONCRETE

LIFE CYCLE ASSESSMENT OF PRECAST CONCRETE COMMERCIAL BUILDINGS: CRADLE-TO-GRAVE[1]

SUMMARY OF CONCRETE FINDINGS

In order to better understand concrete's environmental performance in the context of building construction, use, and end-of-life, a life cycle assessment (LCA) of a typical commercial building with variations of building envelope and three variations of structural framing in two Canadian locations was conducted. The building types were modeled in two cities representing two Canadian climates: Vancouver, British Columbia—a cool climate (Climate Zone 5C)—and Toronto, Ontario—a cold climate (Climate Zone 6A). This LCA study [(1)] was a cradle-to-grave LCA, done in accordance with ISO standards. Since the LCA included a comparative assertion intended to be disclosed to the public, an independent external committee of LCA and technical experts critically reviewed the methodology and results.

Building Envelope Type and Abbreviation	Structure Type and Abbreviation		
	Steel (S)	Cast-in-place Concrete (C)	Precast Concrete (P)
Curtain Wall (CW)	CW-S	CW-C	CW-P
Precast Concrete (P)	P-S	P-C	P-P
Insulated Precast Concrete (Pi)	Pi-S	Pib-C	Pi-P
Insulated Precast Concrete and Thin-Brick Veneer (Pib)*	Pib-S	Pib-C	Pib-P

**Note: The Thin-Brick Veneer utilized bricks 13-16 mm (1/2 to 5/8") thick, cast into the face of the precast concrete panels.*

<u>Concrete Call-outs</u>

1. **During Occupancy** (60 and 73 year scenarios) the buildings with the **lowest global warming potential** (GWP), regardless of location and service life, were the buildings with precast concrete envelope and cast-in-place concrete structure (P-C, Pi-C, and Pib-C).

2. **During Occupancy** (60 and 73 year scenarios), as with GWP, the buildings with the **lowest total primary energy** (TPE), regardless of location and service life, were the buildings with precast concrete envelope and cast-in-place concrete structure (P-C, Pi-C, and Pib-C).

3. **During Occupancy** (60 and 73 year scenarios), the buildings with the **highest TPE and GWP** (60 and 73 year scenarios) were all **steel structures**, regardless of location and service life, with curtain wall envelope and steel structure (CW-S) having the highest TPE and GWP in all cases.

4. With energy simulation, it was found that the **interior thermal mass inherent in cast-in-place concrete and precast concrete floors** (compared to concrete toppings on

metal deck) **reduced annual heating energy use** by 6 to 15% and reduced annual energy use by 2 to 3%.

5. **Operating energy** was responsible for 54 to 75% of the GWP in Vancouver (the range represented service lives of 60 and 73 years, respectively), and in Toronto, 90 to 91% of the GWP was due to operating energy (dependant on service life).

6. **Operating energy** accounted for 90 to 97% (depending on location and service life) of the cradle-to-grave embodied energy (TPE).

7. For all the building types in Toronto and Vancouver, for operating energy from cradle-to-grave, **electricity use was responsible for the majority of impacts** in most of the impact categories, including: global warming, acidification, respiratory effects, eutrophication, photochemical smog, solid waste, ozone depletion, and total primary energy; both fossil and non-renewable.

Portland Limestone Cement (PLC)

When **Portland Limestone Cement (PLC)** was used in the manufacture of precast concrete and the production of cast-in-place concrete, **environmental impacts were reduced**. The GWP is reduced 6 to 9% and total primary energy is reduced 4 to 7%. Although the absolute reduction is higher for precast concrete, the higher percent in these ranges are cast-in-place concrete because there is less portland cement per cubic metre on a mass-basis compared to precast concrete. There were also significant reductions in impacts associated with acidification, respiratory effects, eutrophication, smog, water use, non-renewable energy, and renewable energy (non-biomass).

Over the life of the buildings, when PLC is substituted for RPC in concrete at the rate of 12%, the environmental impacts are reduced. The data showed that a 12% replacement of PLC for RPC, reduced the GWP by approximately 60,000 kg CO2 eq. The entire reduction occurred in the manufacturing stage. Since the absolute GWP of the of the buildings in Vancouver was less than those in Toronto, the relative reduction due to PLC was less in Toronto than in Vancouver, but the absolute reduction was approximately the same. Comparing just the manufacturing stages, the percent reduction was approximately 5% (4.6% in Toronto, 4.7% in Vancouver). When compared from cradle-to-grave, the percent reduction was 1.6 to 1.8% in Vancouver and 0.3 to 0.4% in Toronto.

Other Significant Impact Categories

1. The three buildings with the **lowest acidification potential** in Toronto were the buildings with conventional precast concrete envelope and cast-in-place concrete structure (P-C, Pi-C, and Pib-C).

2. The six buildings with **the lowest respiratory impact** in Toronto were buildings with precast concrete envelopes.

3. The three buildings with the **lowest photochemical smog** potential in Toronto were the buildings with precast concrete envelope and cast-in-place concrete structure (P-C, Pi-C, and Pib-C).

4. Buildings with precast concrete or cast-in-place concrete structures had **less impact in the water use category** than buildings with steel structure.

5. Buildings with precast concrete or cast-in-place concrete structures **had less abiotic resource depletion** than buildings with steel structure.

The concrete industry is dedicated to developing and promoting low environmental impact building design, complementing such current efforts as the new Energy Code and ASHRAE's Advanced Energy Design Guidelines to encourage the elimination of thermal bridging in building facades and the increased use of thermal mass.

References and Acknowledgements

(1) Life Cycle Assessment of Precast Concrete Commercial Buildings (CPCI 2012)

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