Taking Concrete Steps to a Carbon Neutral Future

CaGBC Innovation Forum: Toronto
March 12, 2020
Introduction
- The significance of embodied carbon
- What is the relationship between cement, concrete and GHG emissions?

Decarbonizing concrete
- How are cement and concrete made?
- What is the industry doing to reduce GHG emissions?
- Is the future of concrete carbon neutral?
- What is your role in reducing concrete’s embodied carbon?

Caution: Material substitution & Lifecycle Assessment
EMBODIED CARBON

Jasper Place Library, Edmonton, AB. Architect: HCMA Architecture + Design
Buildings account for almost 40% of global GHG emissions.

About 25% of building emissions are associated with “upfront” carbon emissions from materials and construction activities.
Timing of emissions ("radiative forcing") give reductions in embodied carbon added climate mitigation value.

These are the carbon emissions from constructing the building – mostly due to materials manufacturing. Reducing these emissions is a near term climate change strategy with immediate benefit, yet there are no policies in place to encourage this.

These are the carbon emissions from operating the building – mostly fossil fuel burned for heating, cooling, lighting and ventilation. These emissions slowly accumulate over time. Reducing these emissions is recognized as important but is a long term climate change strategy.
CEMENT, CONCRETE & GHGs
Concrete is the world’s most important building material …

- Virtually all construction – above and below ground – requires concrete
- Twice as much concrete is used than all other materials combined
  - 4 billion tonnes of cement and over **20 billion tonnes of concrete** are produced globally each year*
  - Second most consumed commodity in the world, second only to water
- Cement is a global commodity, but concrete is inherently local
... and a significant source of GHGs

- Up to **8% of global emissions** come from the cement produced to make concrete*
- **1.5% (10.8MT)** of Canada’s GHG emissions in 2017**
- **Deep cement and concrete decarbonization technologies and strategies are essential to decarbonizing the built environment.**

*Andrew, R.M., Global CO₂ emissions from cement production, Earth System Science Data, 2017

**Environment and Climate Change Canada
Concrete

- Typically 7-15% cement added to water, sand and gravel
- Cement comprises up to 80% of concrete’s carbon footprint

Cement: 7-15% of concrete mix, but 60-80% of the carbon
Multiple pathways needed to reduce emissions

Sources of GHGs in cement production

- **1/3\(^{rd}\) combustion emissions**
  - Can be addressed using lower carbon fuels

- **2/3\(^{rd}\) industrial process emissions**
  - Can only be addressed with:
    - Clinker substitution (blended cements)
    - Cement substitution (SCMs)
    - Material efficiency (optimized design)
    - Carbon capture technologies (which can target the combustion emissions as well)
Decarbonizing our buildings: a shared opportunity
Decarbonizing Concrete (Part I):
What is the industry doing to reduce GHG emissions?
Low Carbon Fuels

- Cost competitive pathway to reduce cement manufacturing emissions by **20-30%**

Low Carbon Cements

- Common mix designs can reduce carbon intensity **by > 30%**
  - Portland Limestone Cement (PLC)
  - Supplementary Cementitious Materials (SCMs)
- Can be optimized to meet specific performance requirements

Place Victoria, Gatineau, built with Contempra-based concrete
Carbon capture, utilization & storage (CCUS): We believe carbon negative cement is the future
A selection of active CCUS technologies
Recent western Canada CCS developments ...

- **Lehigh Hanson** - $3 million advanced feasibility study for full-scale CCS at Edmonton, AB cement facility

- **Lafarge Canada** completes installation of CCS flu gas pre-treatment system at Richmond, BC cement facility
Decarbonizing Concrete (Part II): What you can do
Design and specification GHG touchpoints

- Low carbon concrete strategies
  - Low Carbon Cements
  - Mix optimization and Material efficiency
  - Design for carbonation
- Concrete’s role in building performance
  - Thermal mass
  - Resilience/longevity
Know your concrete

- Standard mix designs save embodied carbon (by over 30%) – often without additional cost
- New tools emerging to help with project specific mix optimization decisions.

Source: CMRCA Member Industry-Wide EPD for Canadian Ready Mixed Concrete
Specifications should be tailored to required performance

Government of Canada actively looking at similar requirements for federal infrastructure through “Low Carbon Assets through Life Cycle Assessment” initiative

### Table 19.07.050 Cement and Embodied Carbon Limit Pathways

<table>
<thead>
<tr>
<th>Minimum specified compressive strength $f_c$, psi (1)</th>
<th>Maximum ordinary Portland cement content, lbs/ft$^3$ (2)</th>
<th>Maximum embodied carbon, kg CO$_2$/m$^3$, per EPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 2500</td>
<td>362</td>
<td>260</td>
</tr>
<tr>
<td>3000</td>
<td>410</td>
<td>289</td>
</tr>
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<td>4000</td>
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<td>7000</td>
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<td>up to 3000 light weight</td>
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<td>578</td>
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<tr>
<td>4000 light weight</td>
<td>571</td>
<td>626</td>
</tr>
<tr>
<td>5000 light weight</td>
<td>628</td>
<td>675</td>
</tr>
</tbody>
</table>

**Notes**

(1) For concrete strengths between the stated values, use linear interpolation to determine cement and/or embodied carbon limits.

(2) Portland cement of any type per ASTM C150.

*Source: Bay Area Low-Carbon Concrete Codes Project*
Concrete naturally absorbs carbon from the air over its life.

Rate of carbon uptake depends on exposure to air, atmospheric conditions, concrete composition etc.

Could represent >20% of the industrial process emissions associated with cement content.

Exposed concrete maximizes the effect.

End of life strategies to optimize (re)carbonation are also being explored.
Optimized Building Performance

- Thermal Mass & Energy Management
  - Moderates indoor temperature with **passive energy efficiency benefits of up to 8%**
  - Optimised with smart design, can drive **>60% efficiency improvement**
- Passive survivability
- Resilience, Durability and Longevity
  - Overlooked carbon reduction strategy
  - Repurpose existing structures
Material substitution and Lifecycle Assessment: 
It’s complicated!
Case Study: Should we just build with wood?

Serious about addressing climate change? Build with wood

By Paul Lansbergen | July 5, 2016, 4:02pm

Resources & Agriculture

Graph showing comparisons between different materials:
- Total Energy Use
- Greenhouse Gas Index
- Air Pollution Index
- Soil Eutrophication

FP INNOVATIONS, one of the world’s largest forest research centers, estimates a single 160,000-square-foot wood-based building is the equivalent of taking 1,400 cars off the road each year.
Market confusion: data, scope, boundaries, assumptions, rigor etc.

Source: Canadian Wood Council

*ICF = Insulated Concrete Form
Source: MIT Concrete Sustainability Hub
Decisions need to be based on the best possible environmental information and data
Q: Which material is better for the climate?
A: It’s complicated!
Real world data … assumptions matter!

‘Logging scars’ show impact of deforestation in Canada is worse than we know, research finds

Roads, pits and other ‘logging scars’ have caused underreported environmental damage to forests, with hidden costs for Canada’s carbon footprint, according to researchers who scoured the landscape to see the impact from above.

IVAN SEMENIUK › SCIENCE REPORTER
PUBLISHED DECEMBER 3, 2019
UPDATED 2 HOURS AGO

"… Ontario’s boreal-sourced wood products come with an estimated carbon cost of 119 kg CO2/m3. This carbon cost must be factored into Life Cycle Assessment (LCA)…in addition to any other carbon debt incurred by logging …"
The most effective way to reduce GHGs from buildings is to:

- Use **transparent LCA** to look at the whole picture, supported by robust standards and data
- Make **energy efficiency, long service life** and **material efficiency** the priorities for decarbonizing the built environment
- Support low carbon **innovation across all materials**
Thank you!