Building Better in the Kootenays

Addressing Embodied Carbon in Concrete

Why is it important to address?

One of the key ingredients in concrete is a chemical substance and binding agent called cement. The process of making cement is highly carbon intensive due to the energy required to heat up the materials and the chemical reactions produced when the mixture is exposed to heat. It is estimated that cement production alone contributes approximately 8% of total global greenhouse gas emissions (Ellis, et al., 2019). Cement is mixed with sand, gravel, and water to create the second most consumed material in the world: concrete. **Concrete is important to address because of both the emission intensive processes associated with producing it and the sheer quantity of it that we produce.**

What actions can we take?

- **Use lower carbon concrete**

  Where concrete use is deemed necessary, efforts should be made to ***procure lower carbon concrete mixes***.

  Lower carbon concrete normally means using less cement and ***more Supplementary Cementitious Materials (SCMs)***. This does not meaningfully impact strength. The most commonly used SCMs are fly ash, a by-product of coal production, and slag, a by-product of the iron industry. Higher proportions of unprocessed ground limestone and calcinated clay are also being proposed as alternative SCMs. A mix with up to 30-40% SCMs can be used without requiring an engineer and significantly altering curing times.

- **Reduce concrete consumption**

  One of the most effective ways of reducing emissions is by ***reducing material consumption*** (i.e., less concrete).

  Here are some ways to design with less concrete: ***only build concrete walls in below-grade applications***, consider ***pier foundations*** instead of a closed crawlspace, and ***avoid concrete toppers*** for radiant in-floor heating

2 key terms to know before diving into innovations happening in the concrete sector:

Carbonation refers to the process of alkaline components of cement materials reacting with the CO^2 from the atmosphere. This process is harmful to the strength of the concrete (chiefly if it reaches the steel reinforcements) but does result in the reabsorption of carbon. It is important to note however that as atmospheric CO_2 increases, concrete service lifespans will decrease, and higher strength and higher emissions concrete will become necessary. It should also be noted that the reabsorption capacity is dependent on the surface area exposed to the atmosphere. Much of the concrete in buildings is not exposed and therefore if carbonation is accounted for, it should be done at the end of the building's lifecycle once the concrete is crushed.

Carbon Injection / CO_2 Mineralization in concrete refers to the process of injecting CO_2 into a concrete mix. There has been substantial attention paid to this innovation but there remains work to be done to ensure that this process contributes to fewer overall emissions. This process is not currently resulting in substantial emissions reductions but is a promising innovation with potential to do a lot of good.

Want to take action?

Here's what to ask for at your local concrete mixing plant and/or ask of your local concrete suppliers:

Specify:

30-40% Fly Ash Content

Inquire About:

The impact of higher SCM concrete on curing times and project timelines. Your local concrete experts will have recommendations on how best to build with these mixes.

What are some practical examples of lower carbon building practices?

The following calculations are modelled on a 1,000 sq ft building and rely on embodied carbon data available through the BEAM estimator tool. These examples are intended to demonstrate the impact that design changes can have on the upfront embodied carbon (i.e., extraction and manufacturing emissions) of a project.

BASEMENT 8'

Regular Formed

8" concrete + rebar	7,750
2x6 framing 24" OC	187
Reduced GWP XPS	3,105
Fibreglass R22	251
Concrete Footings & Slab	4,846
=	**16,139 kg CO_2e**

ICF

EPS foam & 15M rebar	2,396
6" Concrete	5,363
Concrete Footings & Slab	4,846
=	»» **12,605 kg CO_2e**

28% reduction

CRAWLSPACE 32"

ICF Crawlspace

6" Concrete	1,790
EPS foam & 15M rebar	800
Concrete Footings & 2" skim coat	3,409
=	**5,999 kg CO_2e**

Pier Foundation

8" x 8" Concrete Piers	327
Concrete footings	634
=	»» **961 kg CO_2e**

84% reduction

SLAB

Slab Foundation

4" Concrete	3,031
=	**3,031 kg CO_2e**

'Concrete-Free' Slab

2x4 sleepers & 2 layers of 5/8" plywood	690
=	»» **690 kg CO_2e**

77% reduction

How does this relate to the Kootenays?

The City of Nelson and City of Castlegar recently completed a study that assessed the upfront embodied carbon emissions associated with new Part 9 home construction. One of the key findings of this study is the outsized role that concrete plays in contributing to the embodied carbon emissions of a building. This finding was supported by subsequent studies in Toronto and Vancouver. In all three studies, **concrete contributed the most emissions as compared to any other material category (e.g., insulation, cladding, etc.).**

- In Nelson & Castlegar, concrete contributed **~35%** of total upfront embodied carbon emissions from the 34 homes analyzed.
- In Toronto, concrete contributed **~33%** of the total upfront embodied carbon emissions from the 503 homes analyzed.
- In Vancouver, concrete contributed **~36%** of the total upfront embodied carbon emissions associated with the 13 homes analyzed.

Federal and provincial governments have begun to signal their intentions to develop low-carbon concrete procurement requirements due to the substantial emission reduction opportunities that concrete and cement present (e.g., the Canadian Standard on Embodied Carbon in Construction). As a result of this action and others, industry has begun to adapt. Kootenay communities will benefit from getting ahead of these sectoral transformations. Supporting local industry as they adapt to a rapidly changing regulatory climate will be crucial to making ambitious emission reductions targets a reality.

Did you know that the City of Nelson is working with a local concrete mix facility, *Nelson Ready Mix*, and a prominent concrete supplier, Rokform Solutions Ltd., to make sure lower carbon concrete is accessible? Public-private collaboration will be an important piece of successfully finding ways to reduce the emissions impact of construction practices and increase the resilience of our building stock. This project demonstrates a meaningful commitment to collaborative work and an opportunity to achieve significant emissions savings.

Low Carbon Homes Pilot Project Team

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Mike Coen
Build Environmental
Builder & Embodied Carbon Specialist

Michele DeLuca
Harmony Engineering
Energy Advisor & Embodied Carbon Specialist

Natalie Douglas
City of Nelson
Climate Resilience Planner & Project Lead

This brief was compiled with information from the following sources:

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