Innovations in Sustainability for Concrete Pavements Low Carbon Concrete for Airport Infrastructure

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SWIFT
SEPT 25-28 2023 WINNIPEG

Aviation Events Group

Content

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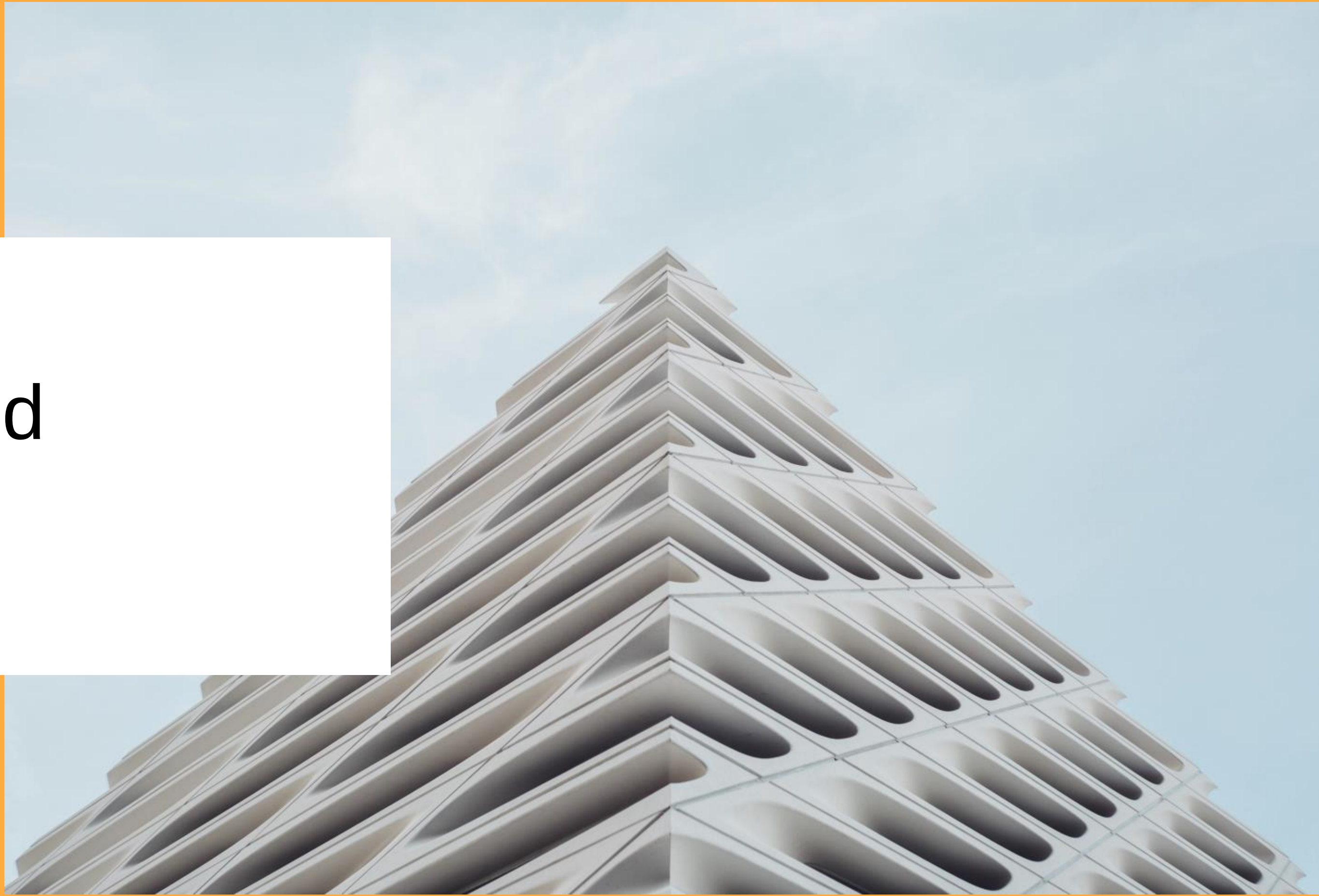
Embodied Carbon



What is Embodied Carbon?

- Embodied Carbon of **Materials**
  - Extraction and manufacturing
- Embodied Carbon of **Buildings**
  - Materials + transportation, construction
  - (sometimes) end of life carbon impacts

i.e. ***"upfront"*** *carbon*

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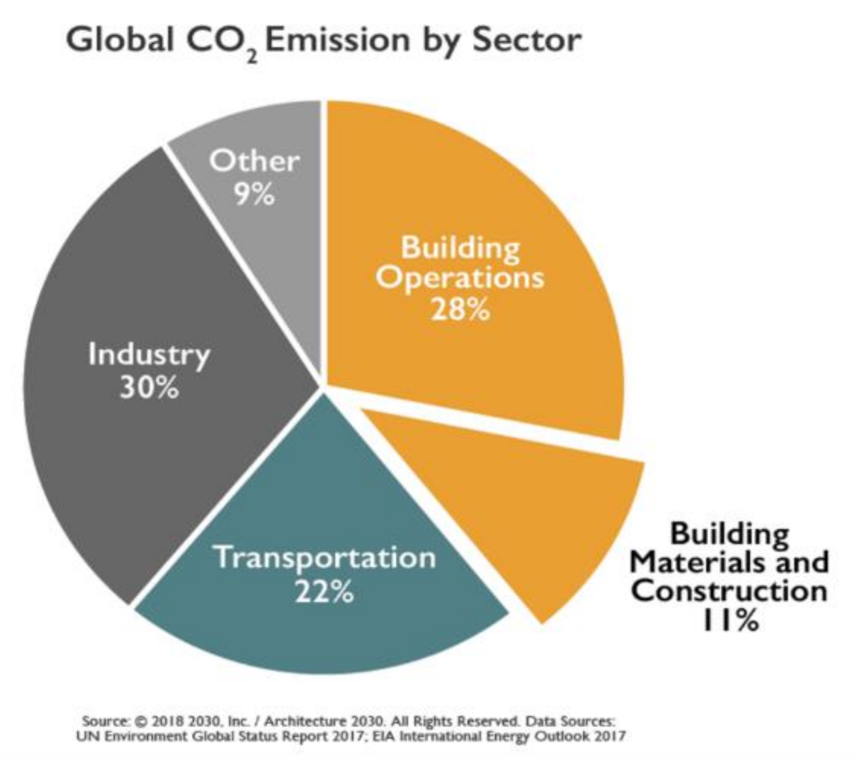
Embodied Carbon is a Significant Source of Emissions

- 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



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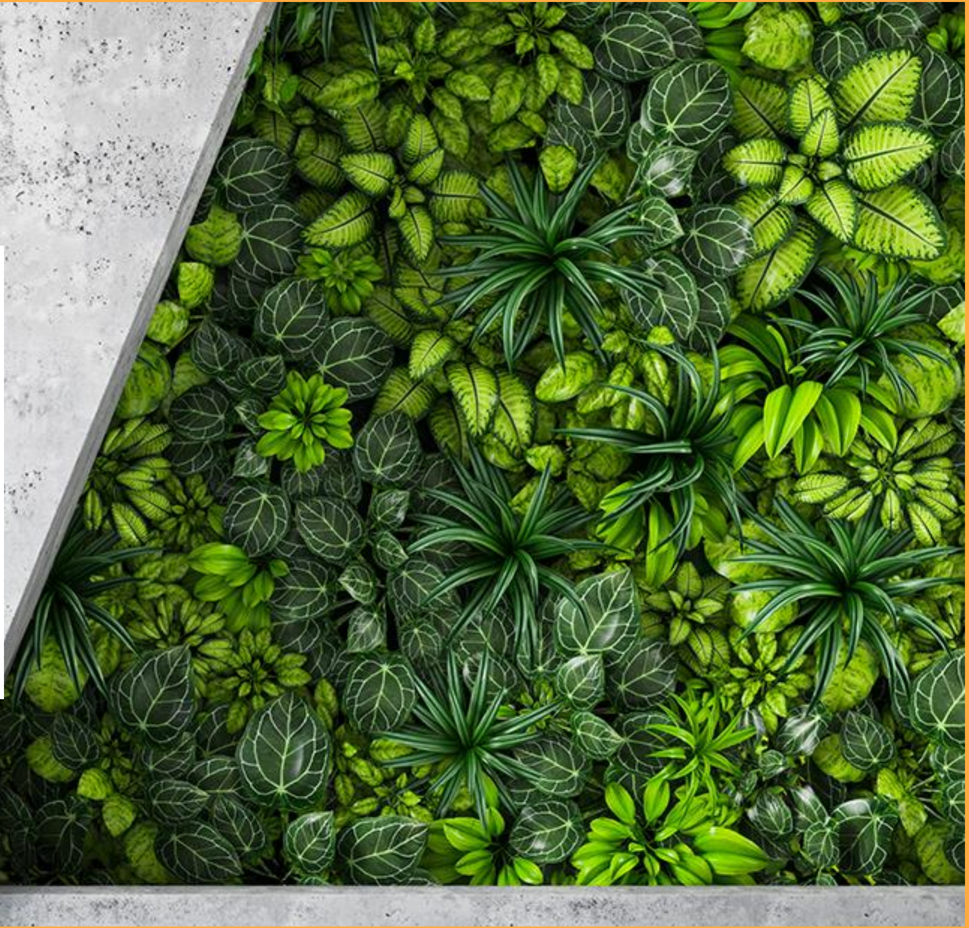
Cement, Concrete and GHGs



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

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Jasper Place Library, Edmonton

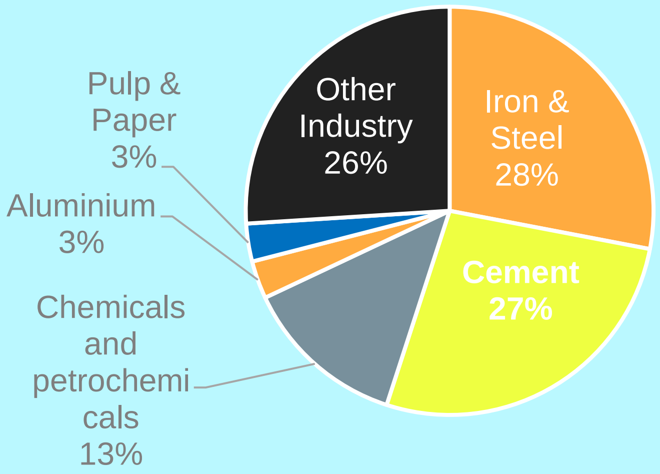

Confederation Bridge, New Brunswick / PEI

… and a Significant Source of GHGs

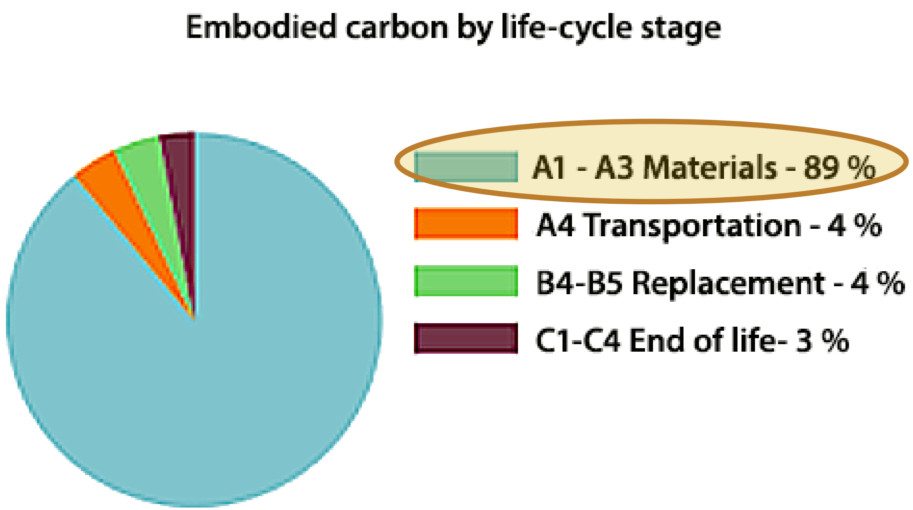
- Up to **7- 8% of global emissions** come from the cement produced to make concrete*
- **1.5%** (10.8MT) of Canada's GHG emissions in 2017**
- Deep cement and concrete decarbonization technologies and strategies are essential to decarbonizing the built environment.

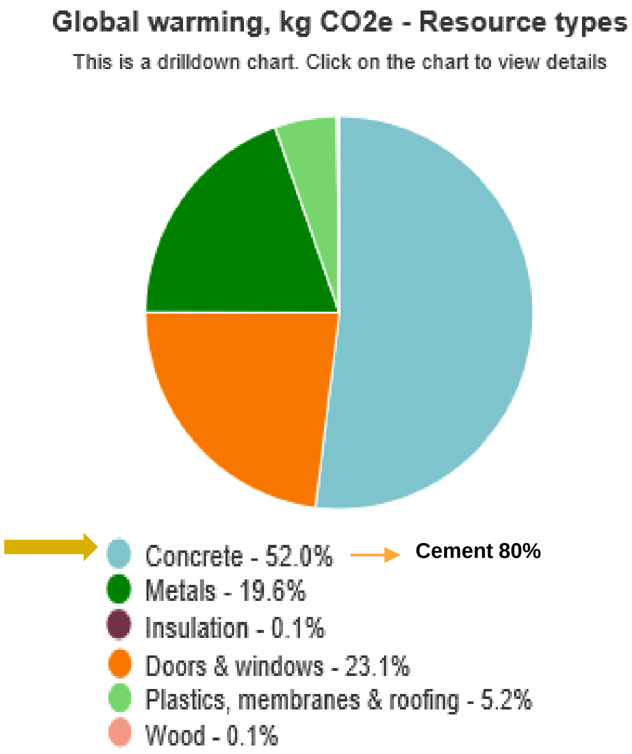
*Andrew, R.M., Global CO_2 emissions from cement production, Earth System Science Data, 2017
**Environment and Climate Change Canada

Global direct industrial CO_2 emissions (2014)



Example: Office Building





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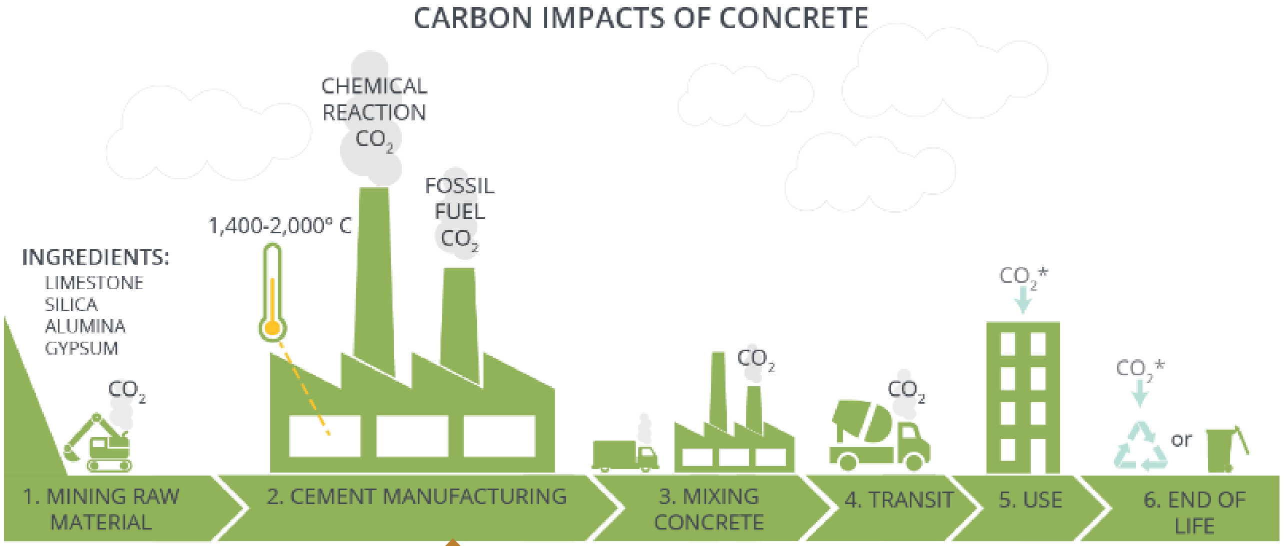
Concrete Carbon Lifecycle



Despite representing only 10-15% of the concrete mix, cement contributes 80-85% of the total carbon footprint

END OF LIFE:
Over 95% of concrete is recycled at the end of its useful life, either ground up to make concrete aggregate or even new concrete

Example Mix – with air
A 30MPA concrete mix has a GWP of 329.02 kg eCO_2/m^3,
cement representing 260-280 kg eCO_2/m^3

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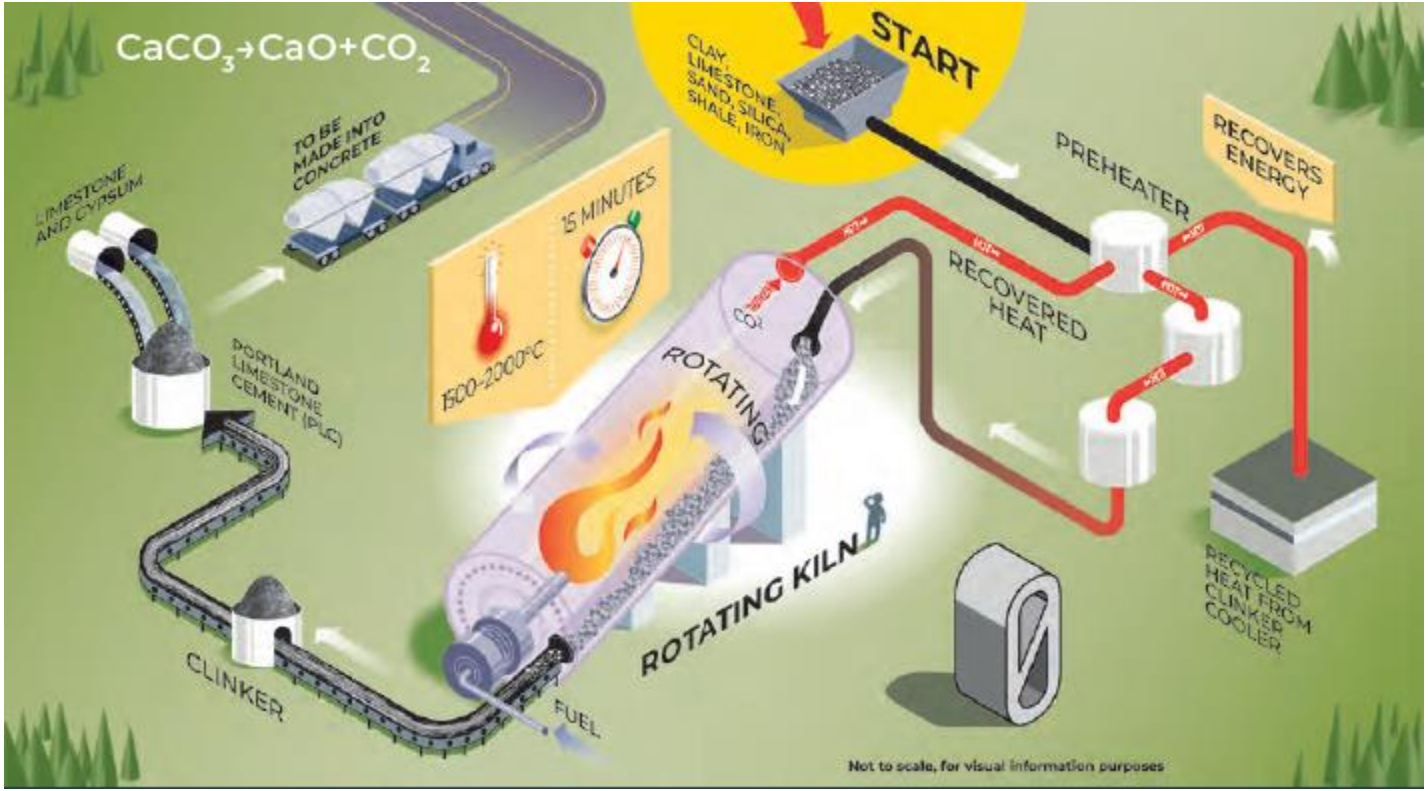
Note: Concrete EPDs cover A1 to A3 Cradle to Gate analysis

Cement Manufacturing

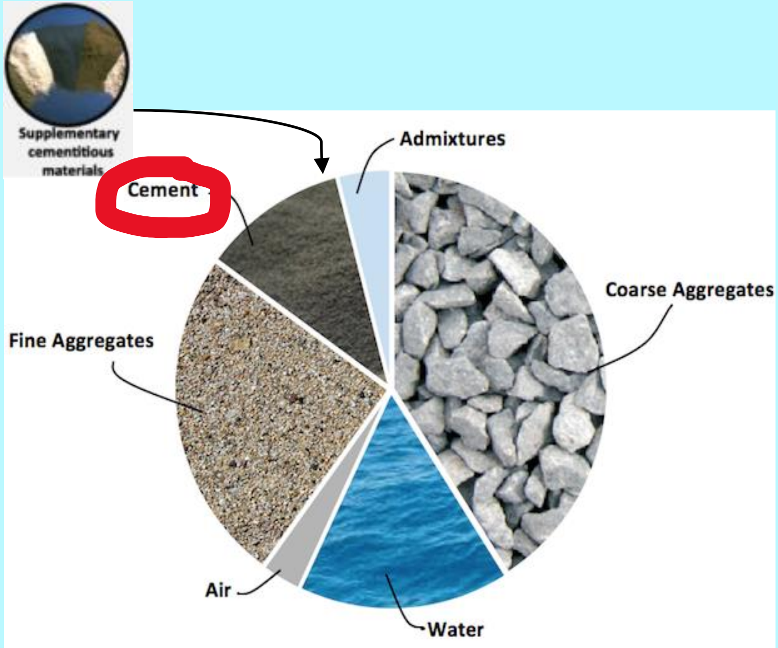


Up to 5 % limestone added to create Portland cement

Cement is a Small Part of the Concrete Recipe, but Responsible for Most of Concrete's Embodied Carbon

Concrete

- Typically 7-15% cement added to water, sand and gravel
- Cement comprises up to 85% of concrete's carbon footprint



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Cement and Concrete's Action Plan to Net-Zero

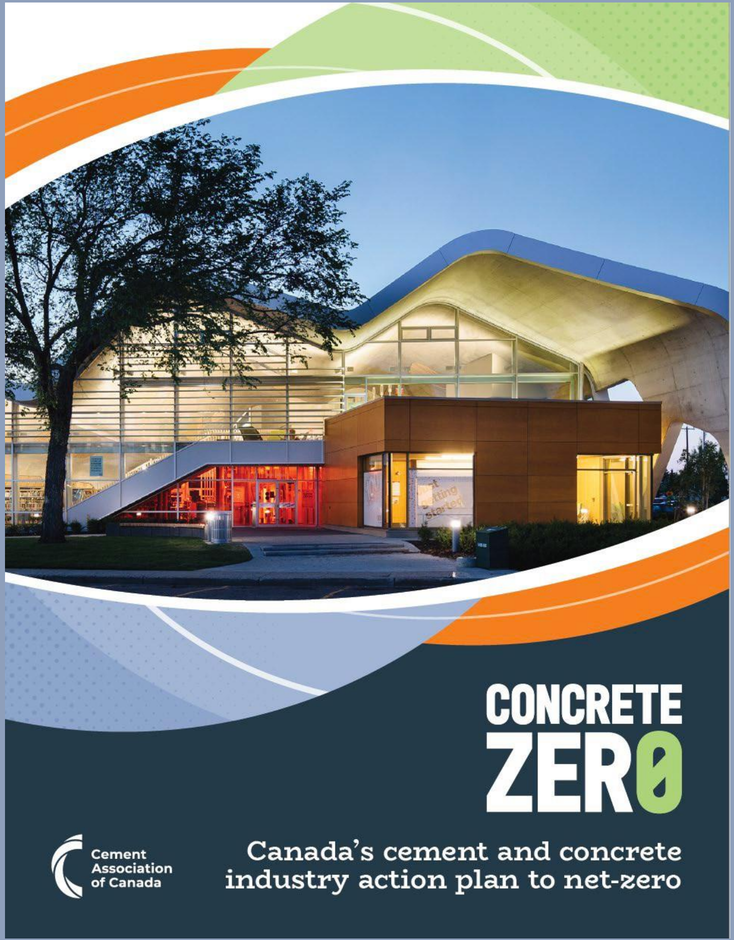
Action Plan to Net Zero

- Outlines the steps that the Canadian cement and concrete sector will take to help Canada achieve its net-zero carbon goals.

- Released on May 2nd, 2023.

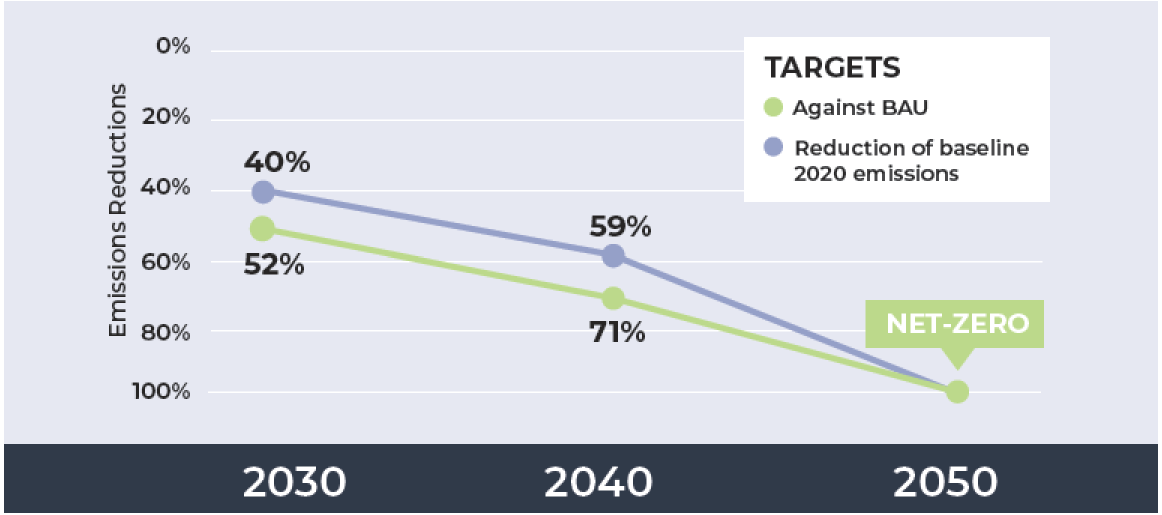
- Supported and featured contributions from our members, and provincial and national concrete producers' associations.

- Contributions and reviewed by Environmental Non-Governmental Organizations, including the Transition Accelerator, Clean Prosperity Institute, and the Canadian Climate Institute.



Carbon Reduction Targets

- Ultimate target is net-zero by 2050.
- Additional reduction targets of 40% by 2030 and 59% by 2040 (usings a 2020 baseline).
- Our Action Plan is about "true net-zero" – we aren't accounting for the purchase of offsets or avoided emissions.



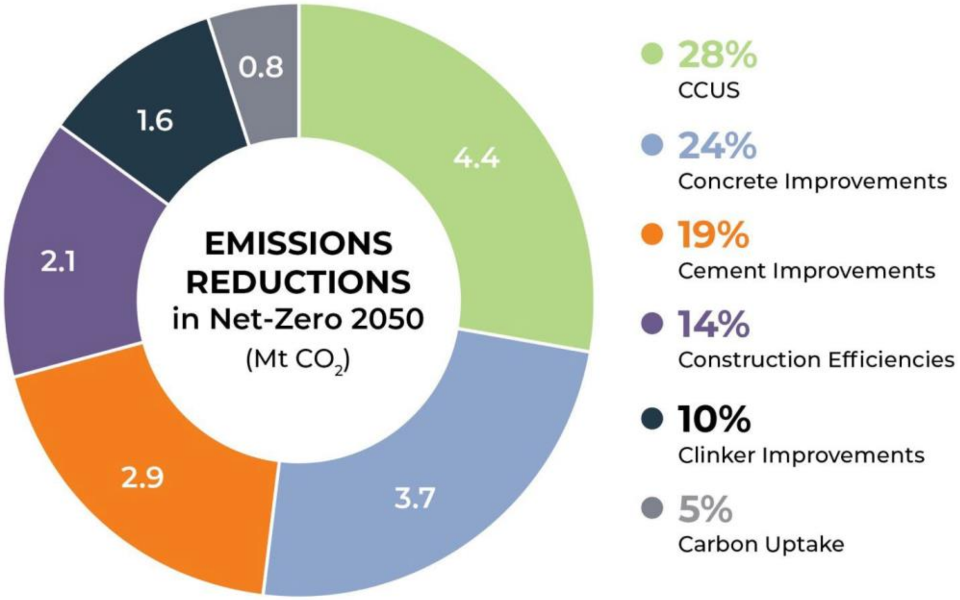
BAU = Business as usual

The Path to Net-Zero

- There is no silver bullet, no one magic solution that will get us to zero. Rather it will take many actions.

- This Action Plan focuses on existing, proven technologies and we will update the plan as more technologies and solutions become commercially available.

- Focus on the 5 C's (clinker, cement, concrete, construction, and carbon uptake)



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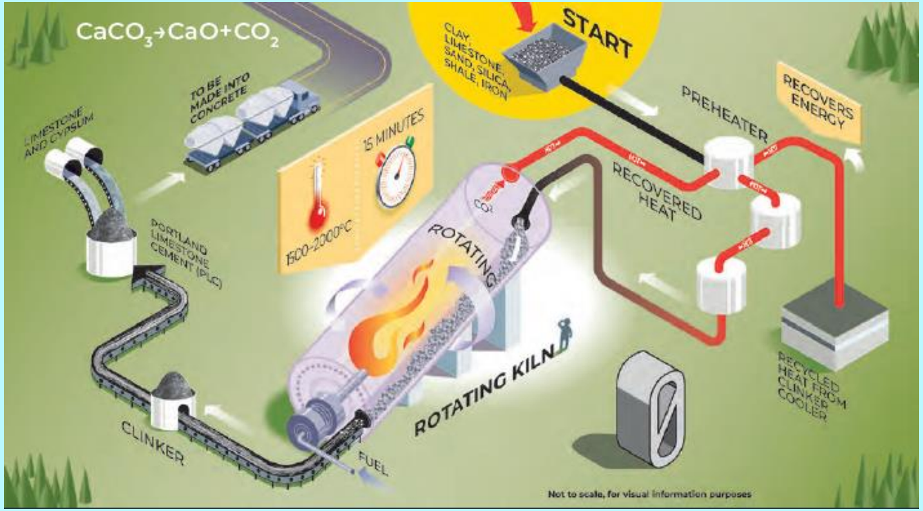
Multiple Pathways Needed to Reduce Emissions

1/3rd combustion emissions

- *Can be addressed using lower carbon fuels*

2/3rd 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)



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Canadian Cement Industry Partnering with Fed. & Prov. Gov’ts. to Lower Carbon Footprint

1. ***Canada’s Cement Industry and the Government of Canada have partnered to establish Canada as a global leader in low-carbon cement and to achieve net-zero carbon concrete.***
2. ***Working together, a reduction of 15 Megatonnes of GHG’s needs to be achieved by 2030. Then on-going additional reductions of 4 Megatonnes annually.***
3. ***We are proud partners of an Industry-Government Working Group that includes the NRC, the SCC, and ISED that are working collaboratively on several activities including broad adoption of Green Procurement Rules with the Treasury Board of Canada Secretariat.***

NRC – Natural Resources Canada,

SCC – Standards Council of Canada,

ISED – Innovation, Science and Economic Development

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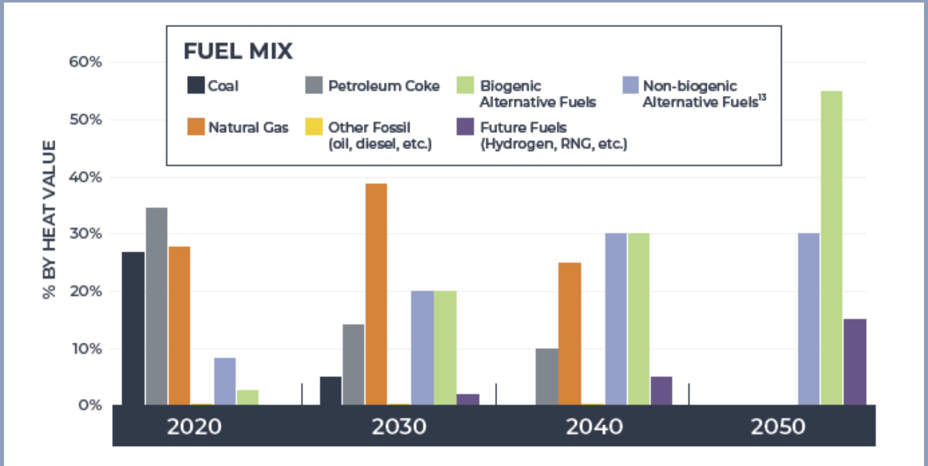
The 5 C's - Cement and Concrete Value Chain

Clinker

- Clinker is the key ingredient that gives cement it's binding properties.
- The most GHG-intensive component of cement.

How we'll reduce clinker emissions:

1. Replacing fossil fuels
2. Clinker substitution
3. Carbon Capture
4. Thermal efficiency
5. Decarbonated raw materials
6. Novel clinker chemistries



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Cement

- The most energy-intensive phase of the concrete value chain occurs at the cement plant

How we'll reduce cement emissions:

1. New cement blends:
   - Portland-limestone cement
   - Supplementary cementitious materials
   - Blended cements

	2030	2040	2050
Blended Cements (% of market)	25%	35%	50%
SCM in Blended Cement (%)	20%	20%	20%
CO_2 Burden of SCMs (Mt CO_2)	0.09	0.1	0.2

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Concrete

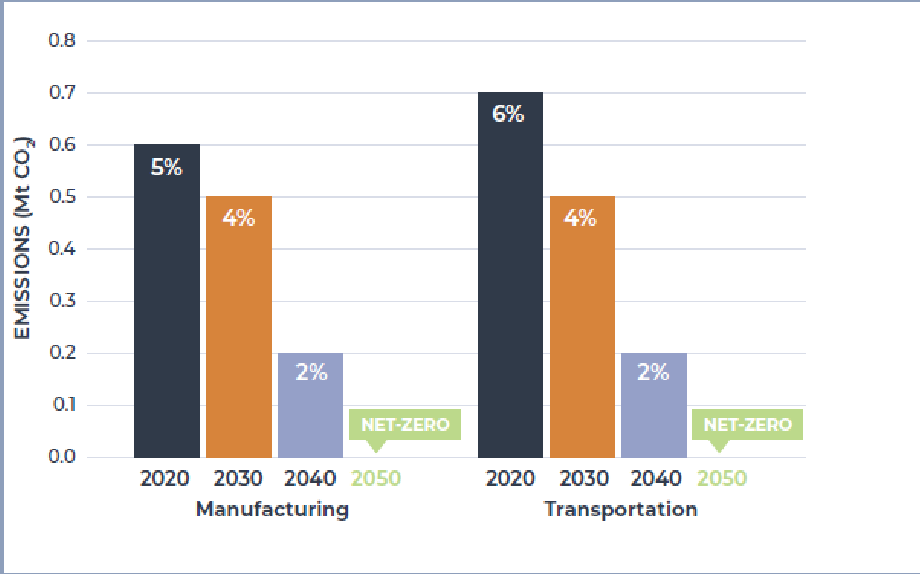
- As an essential building material, concrete must be produced to ensure quality and performance while reducing emissions.

How we'll reduce concrete emissions:

1. Concrete mix optimization
   - Larger aggregate to minimize paste
   - Aggregate gradation optimization
   - Recycled concrete aggregate
   - Utilize chemical admixtures

2. Optimized concrete design to ensure not over specifying strength and durability requirements

3. Powering concrete with clean energy



Construction

- There are opportunities to reduce and avoid the volume of emissions associated with concrete use through design and construction.

How we'll reduce construction emissions:

1. Optimization in design
   - Consider material efficiency (i.e. voided slabs, column spacing, etc.)
   - Avoid over designing
2. Waste reduction

Achieving emissions reductions in construction is outside of the direct control of the cement and concrete industry and requires a shared commitment to achieving net-zero, together.

	2030	2040	2050
Savings from Material Efficiency (millions m^3 of concrete)	3.6	5.9	7.9
CO_2 Reduced at the Construction Stage (in year concrete produced) (Mt CO_2)	0.7	0.9	0.8

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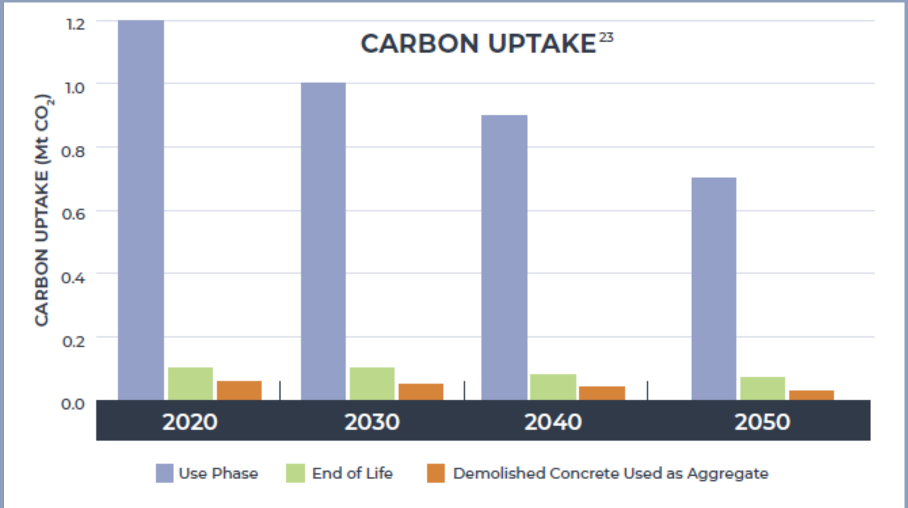
Carbon Uptake

- Concrete naturally sequesters CO2 from the atmosphere, permanently capturing it in a process known as carbon uptake
- Research conducted at IVL, the Swedish Environmental Research Institute, finds an average of 20% of the CO2 calcination emissions can be permanently sequestered when a concrete structure has been built
- During the design phase of a project, a good strategy to maximize CO2 uptake is for architects and engineers to ask to use exposed concrete wherever possible.



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Industry’s Role in Reducing Carbon Intensity of Concrete

Low Carbon Fuels

Objective: Displace fossil fuels with waste products destined for landfill

- Typical substitutes
  - C&D waste (i.e. urban wood)
  - non-recyclable plastics
  - non-recyclable tires
- Future:
  - Biosolids?
  - Renewable Natural Gas?
  - Hydrogen?
- **Reduction Potential: ~ 33%**

Example Mix
30MPA = 386.6 kg eCO_2/m^3
25% LCF can reduce this by 30 kg eCO_2/m^3

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Clinker Substitution

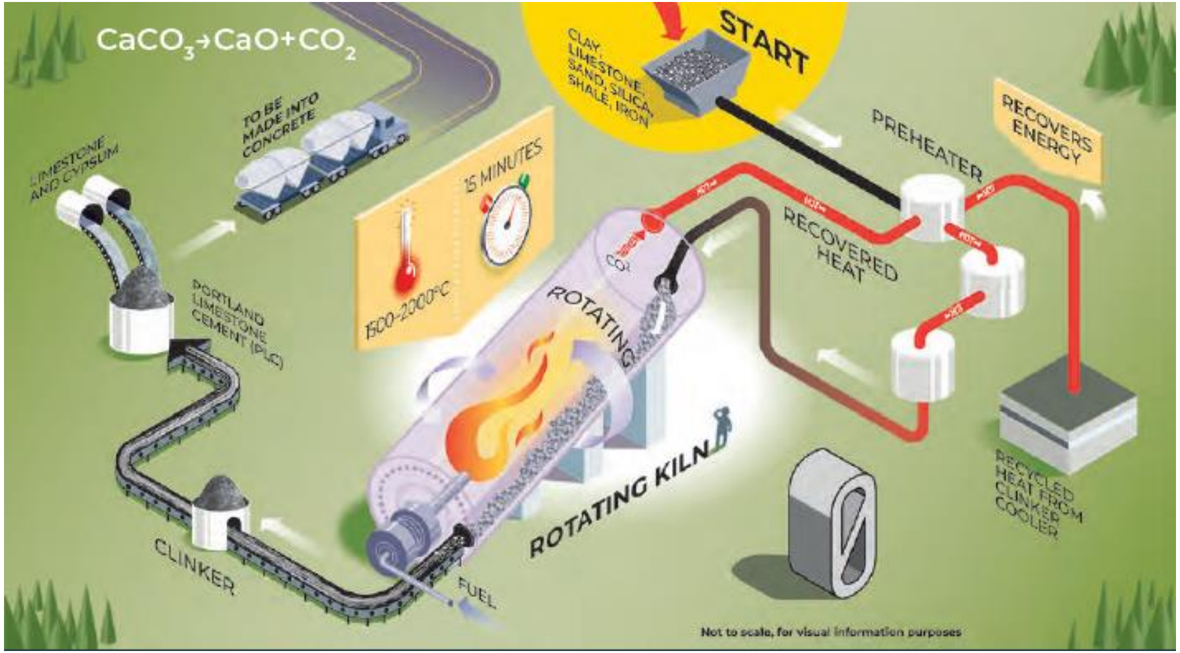
- Objective: substitute clinker (the energy-intensive, intermediate product in the manufacture of cement) with alternative materials that display cementitious properties.

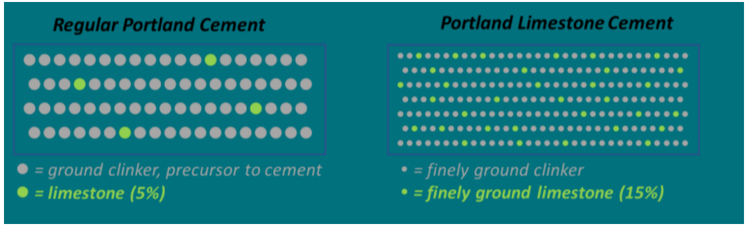
- Alternatives include:
  - Portland-limestone cement
  - Fly ash, slag and other Supplementary Cementitious Materials (SCMs)

National Holocaust Monument – 2017

*

Cement Manufacturing - PLC





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Supplementary Cementitious Materials (SCMs)

- SCMs reduce the cement and clinker content of a concrete mix, providing economic and environmental benefits
- Limits for SCMs outlined by CSA Standard A3001 – Cementitious Materials for Use in Concrete
- The blending or inter-grinding of cement or Portland limestone cement with up to three SCMs

    - Binary – 2, Ternary – 3, Quaternary – 4
- In general, mixtures perform in a manner that can be predicted by knowing the characteristics of the individual ingredients

Library and Archives Canada's New Preservation Facility

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Carbon Capture Utilization and Storage (CCUS)

Carbon capture at the cement plant

- Two full scale pilots under development in Western Canada

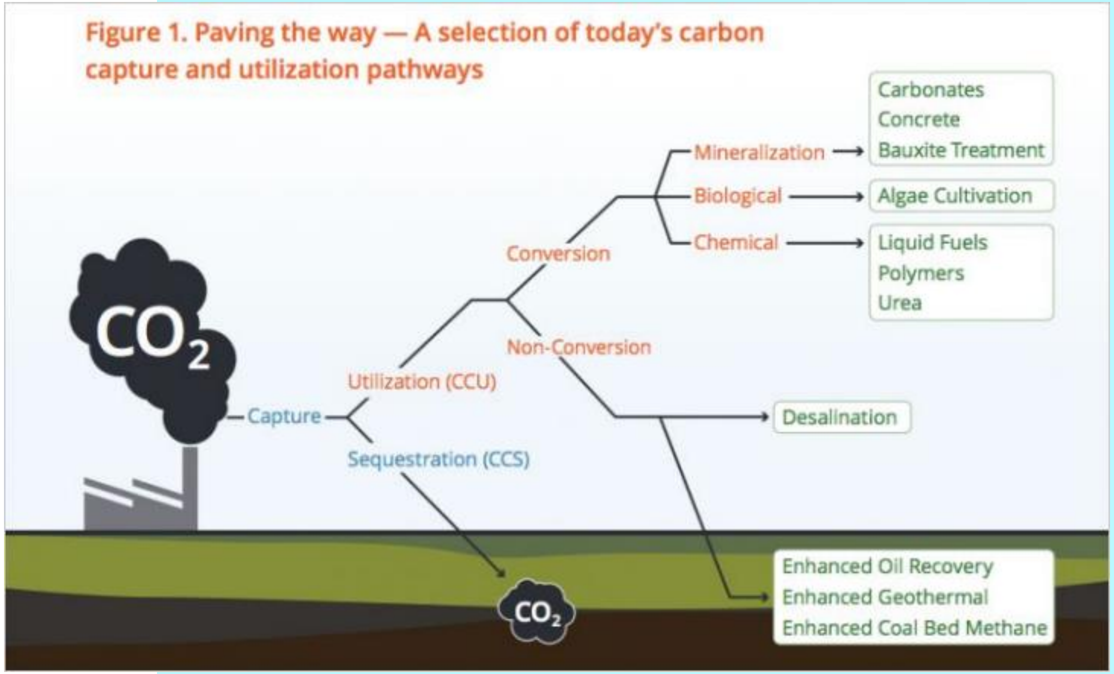
Reduction Potential: 90 – 95%

Carbon utilization in concrete

- Multiple pathways

Reduction potential: 1 – 70%

Future: > 100%??



*

A Selection of Active CCUS Technologies

Carbon8

INTERNATIONAL CCS KNOWLEDGE CENTRE

Carbon Upcycling Technologies

pondtech

SOLIDIA®

Blue Planet™

CO_2 SOLUTIONS

Svante

Carbon Engineering

CARBON CURE™

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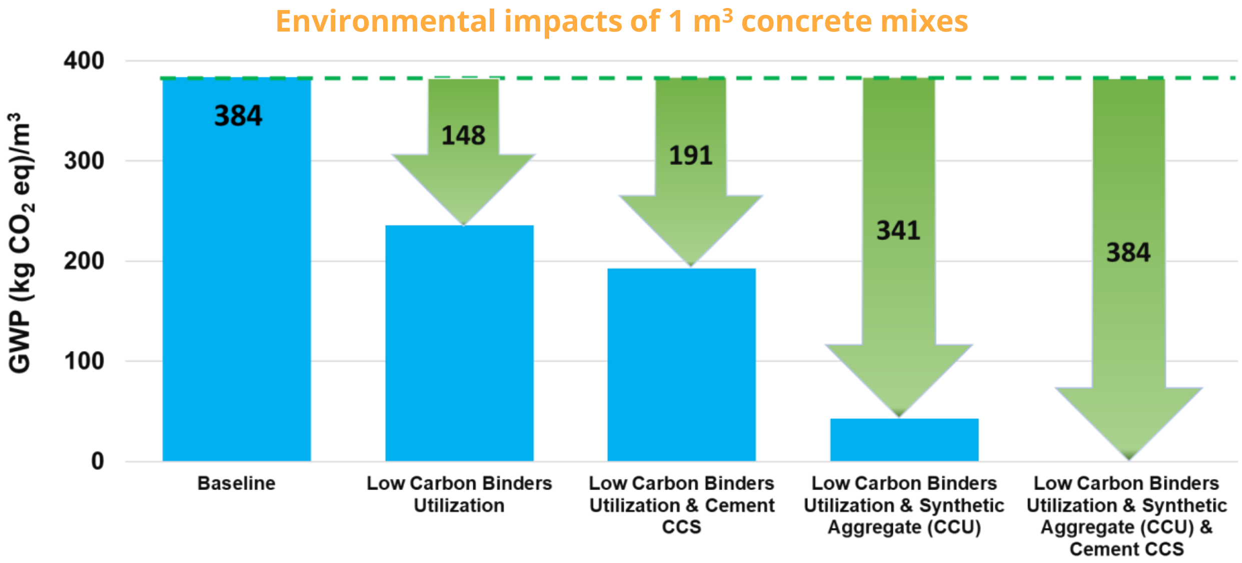
Cumulative Impact of Reductions

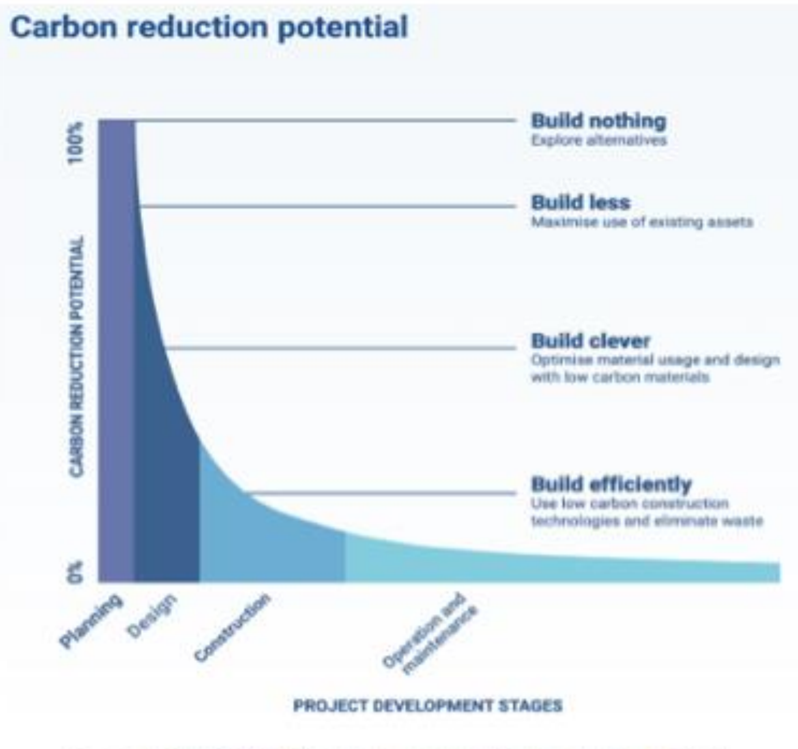


Source: The role of concrete in life cycle greenhouse gas emission reductions of the United States buildings and pavements. Jeremy Gregory, CSHub Webinar, August 20, 2020

Designer's and Owner's Role in Reducing the Carbon Footprint of Concrete

How Architects & Engineers Can Reduce the Carbon Footprint of Concrete

- ✓ Communicate your carbon reduction goals
- ✓ Invest in quality control by purchasing from certified concrete facilities
- ✓ Focus on **performance** rather than prescriptive mix designs
- ✓ Use Portland-limestone cement (PLC)
- ✓ Optimize the use of Supplementary Cementitious Materials (SCMs)
- ✓ Consider material efficiency (i.e. voided slabs, column spacing, etc.)
- ✓ Optimized concrete design to ensure not over specifying strength and durability requirements
- ✓ Use concrete as a finish material to reduce material needs and promote carbonation



(Source: WorldGBC - Bringing Embodied Carbon Upfront, 2019)

Performance-Based Specifications

Giving the ready mixed producers the flexibility to provide concrete that meets the specified performance criteria via the use of a CSA Performance-Based Specification approach will lead to an optimized design AND a more sustainable concrete solution.

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Performance-Based Specifications

PRESCRIPTIVE

It is highly discouraged to specify any mix proportions, including material quantities (e.g., admixtures, aggregates, cementitious materials, and water), as the mix design becomes prescriptive, and the owner assumes full responsibility for the concrete performance.

Using prescriptive mix designs can not only negatively impact the performance of the concrete but can also very likely negatively impact the realization of carbon reduction goals on the project since the specifier will not be aware of the raw materials used by each individual concrete producer or plant.

PERFORMANCE

Performance-based specifications offer the specifier the ultimate peace of mind that the ready mixed producer is responsible for the performance of the concrete as delivered.

They also give the ready mixed producer flexibility in optimizing mix designs.

This flexibility becomes critically important when a ready mixed producer needs to use multiple CSA-approved approaches in designing mixes to meet a variety of requirements including strength, durability, constructability, and carbon/sustainability.

Performance-based specifications are critical to specifying low carbon concrete AND to achieving low carbon concrete.

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CSA Standards

CSA A23.1 & A23.2-19

Definitions of C,F,N,A and S Classes of Exposure

- C –2 Non-structurally reinforced concrete exposed to chlorides and freezing and thawing

Requirements for C,F,N,A and S Classes of Exposure

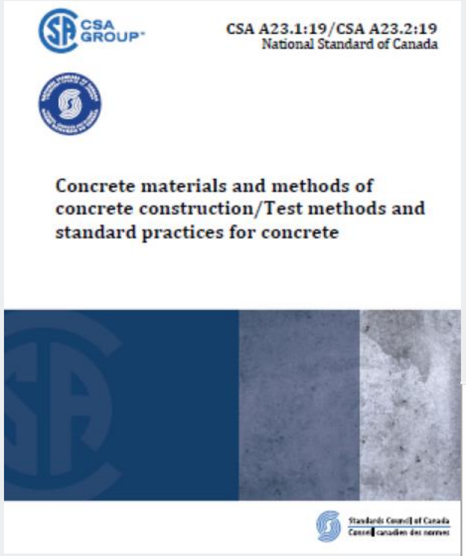
- 0.45 maximum water-to-cementing materials ratio
- 32 MPa minimum specified 28 d compressive strength
- 1 air content category

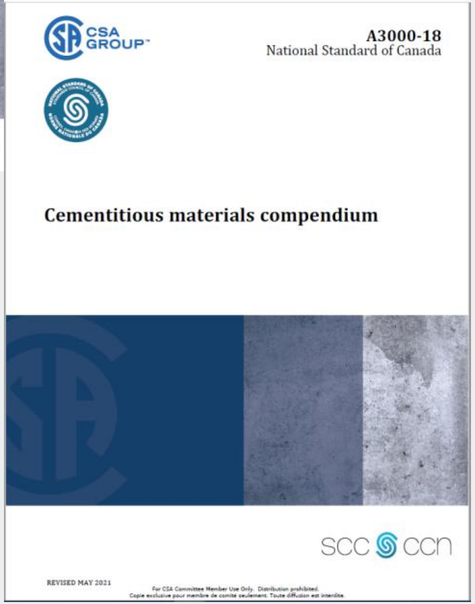
Requirements for the Air Content Categories

- 5 – 8 % for 14 – 20 mm maximum size aggregate
- 4 – 7 % for 28 – 40 mm maximum size aggregate

CSA A3000-18

- Cementitious materials compendium allows the use of PLC in concrete mixes





Exposure Classes

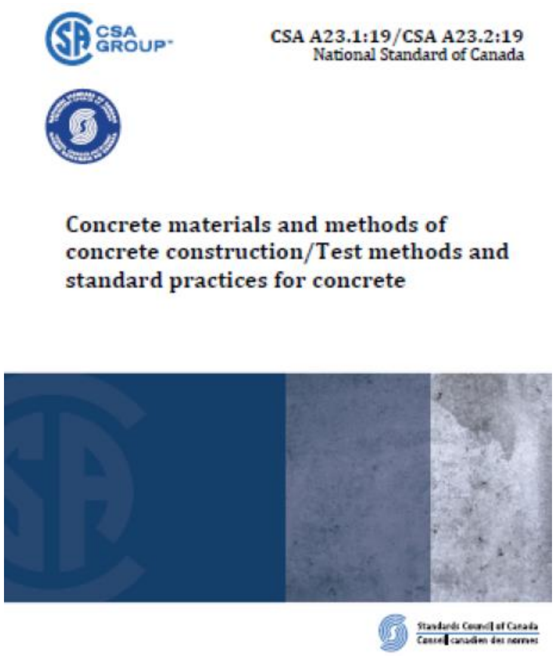


Table 1
Definitions of C, F, N, A, S and R classes of exposure
(See Clauses 3, 4.1.1.1.1, 4.1.1.1.3, 4.1.1.5, 4.1.1.8.1, 4.1.2.3, 6.1.4, 6.6.7.6.1, 7.1.2.1, 9.1, L.3, and R.1, Tables 2, 3, and 17, and Annex L.)

C-XL	Structurally reinforced concrete exposed to chlorides or other severe environments with or without freezing and thawing conditions, with higher durability performance expectations than the C-1 classes.
C-1	Structurally reinforced concrete exposed to chlorides with or without freezing and thawing conditions. Examples: bridge decks, parking decks and ramps, portions of structures exposed to seawater located within the tidal and splash zones, concrete exposed to seawater spray, and salt water pools. For seawater or seawater-spray exposures the requirements for S-3 exposure also have to be met.
C-2	Non-structurally reinforced (i.e., plain) concrete exposed to chlorides and freezing and thawing. Examples: garage floors, porches, steps, pavements, sidewalks, curbs, and gutters.
C-3	Continuously submerged concrete exposed to chlorides, but not to freezing and thawing. Examples: underwater portions of structures exposed to seawater. For seawater or seawater-spray exposures the requirements for S-3 exposure also have to be met.
C-4	Non-structurally reinforced concrete exposed to chlorides, but not to freezing and thawing. Examples: underground parking slabs on grade.
F-1	Concrete exposed to freezing and thawing in a saturated condition, but not to chlorides. Examples: pool decks, patios, tennis courts, freshwater pools, and freshwater control structures.
F-2	Concrete in an unsaturated condition exposed to freezing and thawing, but not to chlorides. Examples: exterior walls and columns.
N	Concrete that when in service is neither exposed to chlorides nor to freezing and thawing nor to sulphates, either in a wet or dry environment. Examples: footings, walls, and columns.
N-CF	Interior concrete floors with a steel-trowel finish that are not exposed to chlorides, nor to sulphates either in a wet or dry environment. Examples: interior floors, surface covered applications (carpet, vinyl tile) and surface exposed applications (with or without floor hardener), ice-hockey rinks, freezer warehouse floors.

Requirements for Various Classes of Exposure

Table 2
Requirements for C, F, N, A, and S classes of exposure
(See Clauses 4.1.1.1.1, 4.1.1.1.3, 4.1.1.3, 4.1.1.4, 4.1.1.5, 4.1.1.6.2, 4.1.1.8.1, 4.1.1.11, 4.1.2.1, 4.3.1, 4.3.7.1, 4.3.7.2, , 7.1.2.1, 7.5.1.1, 8.7.4.1, 9.4, 9.5, L.1, L.3, and R.3 and Table 1.)

			Air content category as per Table 4[d]		Curing type (see Table 19)			
Class of exposure[a]	Maximum water-to-cementitious materials ratio[b]	Minimum specified compressive strength (MPa) and age (d) at test[b, i]	Exposed to cycles of freeze/thaw	Not exposed to cycles of freeze/thaw	Normal concrete	HVSCM-1	HVSCM-2	Chloride ion penetrability requirements and age at test[c]
C-XL or A-XL	0.40	50 within 56 d	1	[e]	3	3	3	< 1000 coulombs within 91 d
C-1 or A-1	0.40	35 within 56 d	1	[e]	2	3	2	< 1500 coulombs within 91 d
C-2	0.45[h]	32 at 28 d	1	n/a	2	2	2	—
C-3	0.50	30 at 28 d	n/a	[e]	1	2	2	—
C-4[e]	0.55	25 at 28 d	n/a	[e]	1	2	2	—
A-2	0.45	32 at 28 d	1	[e]	2	2	2	—
A-3	0.50	30 at 28 d	2	[e]	1	2	2	—
A-4	0.55	25 at 28 d	2	[e]	1	2	2	—
F-1	0.50[j]	30 at 28 d	1	n/a	2	3	2	—
F-2 or R-1 or R-2	0.55[j]	25 at 28 d	2[f]	n/a	1	2	2	—
N	As per the mix design for the strength required	For structural design	n/a	[e]	1	2	2	—
N-CF[g] or R-3	0.55	25 at 28 d	n/a	[e]	1	2	2	—
S-1	0.40	35 within 56 d	1	[e]	2	3	2	—

(Continued)

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Canadian National Master Construction Specification

- **Portland Cement: hydraulic cement, blended hydraulic cement (XXb - b denotes blended) and Portland-limestone cement types:**

  .1 GU, GUb, GUL and GULb - General use cement.

  .2 MS, MSb and MSLB - Moderate sulphate-resistant cement.

  .3 MH, MHb, MHL and MSLB - Moderate heat of hydration cement.

  .4 HE, HEb, HEL and HELb- High early-strength cement.

  .5 LH, LHb, LHL LHLb - Low heat of hydration cement.

  .6 HS, HSb and HSLb - High sulphate-resistant cement.

- **Fly ash types:**

  .1 F - with CaO content maximum 8%.

  .2 CI - with CaO content 15 and 20%.

  .3 CH - with minimum CaO content of 20%.

- **Other Supplementary Cementitious Materials (SCM) types:**

  .1 S-GGBFS - Ground, granulated blast-furnace slag.

  .2 N – Natural pozzolan.

  .3 SF – Silica fume with minimum silicon dioxide (SiO_2) content of 85%.

  .4 SFI – Silica fume with silicon dioxide (SiO_2) content between 75% and 85%.

  .5 GL – Ground glass with maximum total alkali (NaEq) content of 4%.

  .6 GH – Ground glass with total alkali (NaEq) content between 4% and 13%.

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Cast-in-Place Concrete, Section 03 30 00

National Model Codes

- PLC / GUL / GULb recognized in the updated editions of the 2020 Building, Plumbing, Fire and Energy Code of Canada

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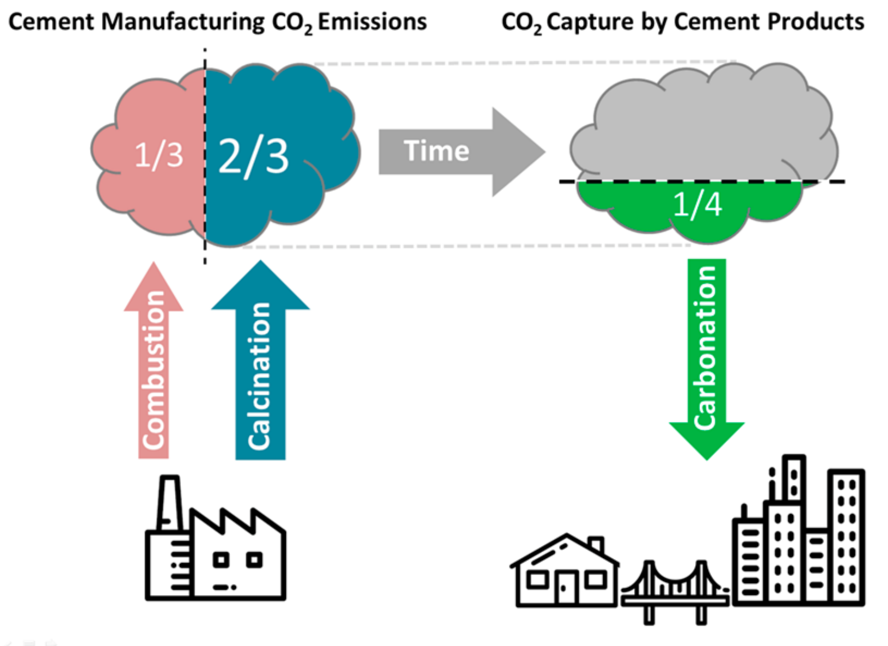
Design for (Re)carbonation (Emerging Science)

- Concrete naturally absorbs carbon 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



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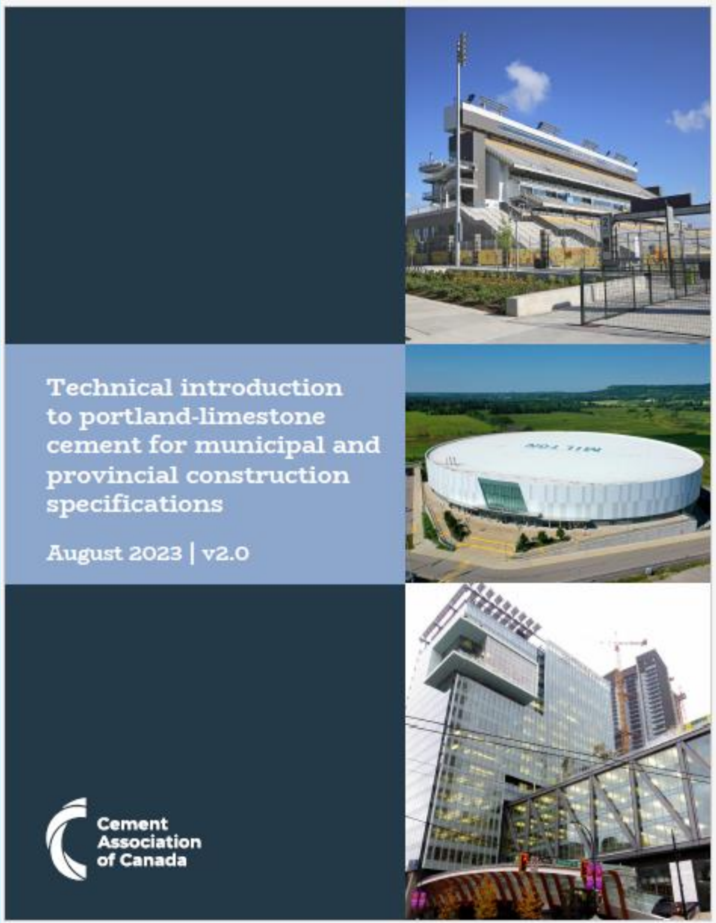
PLC Technical Summary Document

- What / why Portland Limestone Cement
- How is PLC Manufactured
- History of PLC Use
- Testing and Performance
- Use in Other Jurisdictions
- Carbon Reduction Potential
- Summary
- Key Contacts
- References
- Project Examples



https://cement.ca/app/uploads/2023/08/Aug-2023-PLC-Technical-Summary-Report-2.0.pdf

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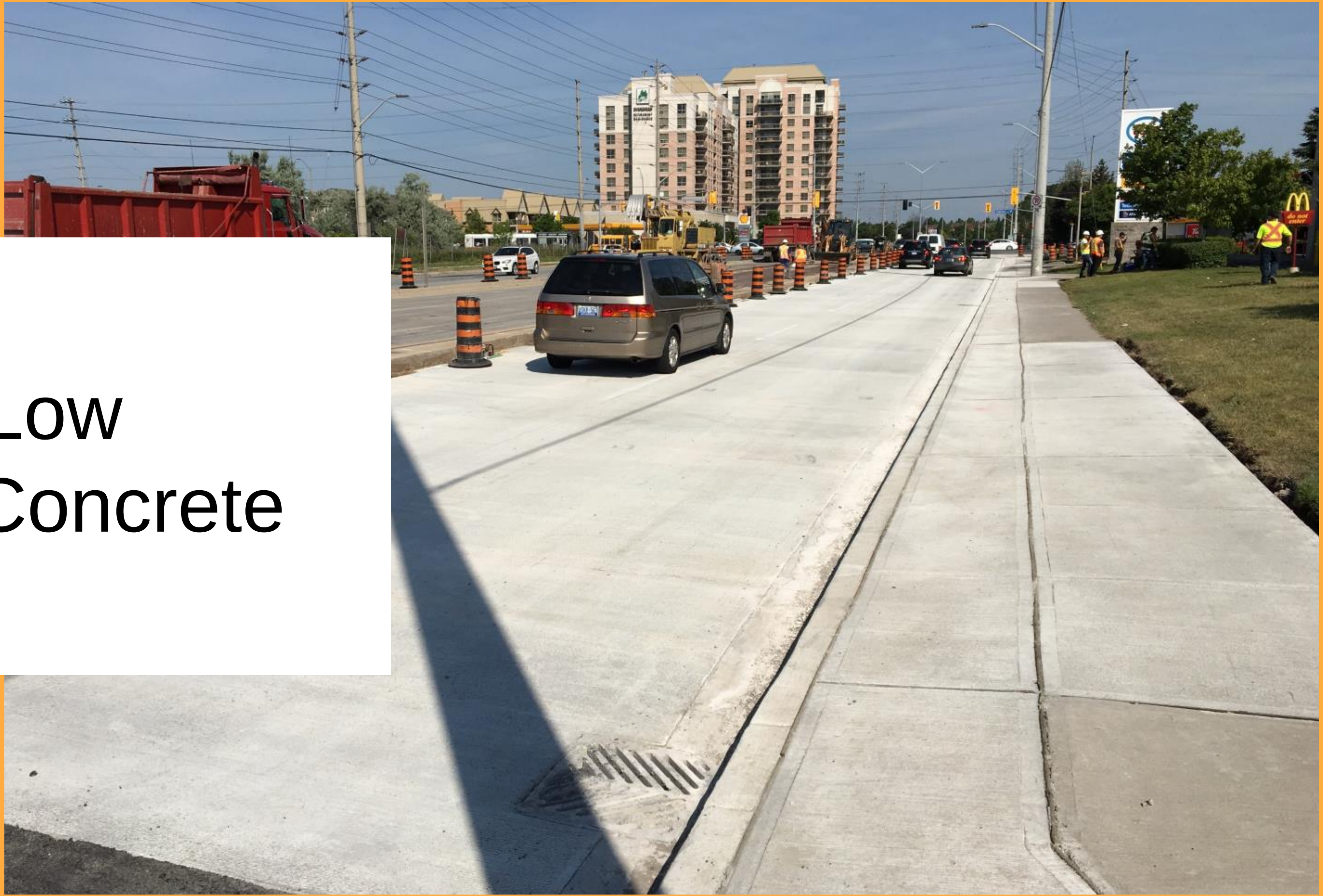

What Is Low Carbon Concrete

What is Low Carbon Concrete?

- Low carbon concrete refers to concrete produced with a **lower carbon footprint** than traditional mix designs, **while still meeting all relevant performance requirements**
    - Strength, permeability, durability, etc.
- To employ low carbon concrete:
    - Use available lower carbon impact materials
    - Mix design optimization (Admixtures)
    - Carbon mineralization technology
    - Tools to quantify the carbon impact (EPDs)
    - Project carbon budgeting

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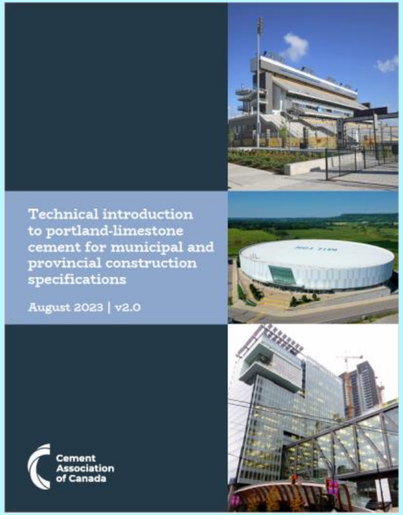
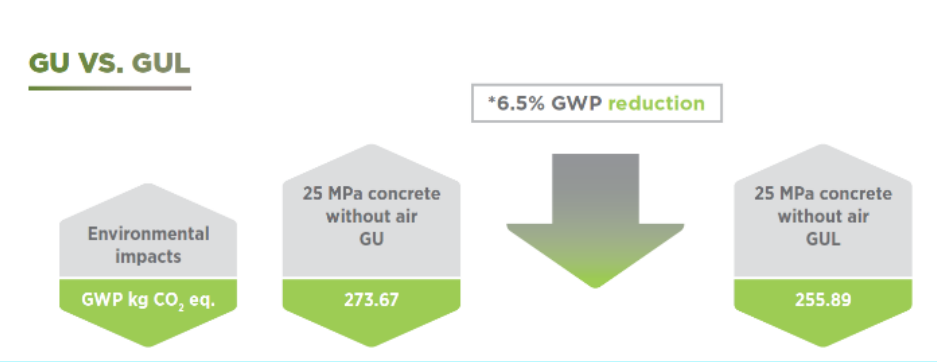
Vancouver Convention Centre – West
First convention Centre in the world to achieve **double LEED Platinum** – the first for Building and Construction (2009; for the lifetime of the building) and the second for Building Operations and Maintenance (2017; renewal in 2022)

Producing Low Carbon Concrete

Evaluating all your Raw Materials

- Utilize raw material EPDs
- Utilize local materials
- Evaluate the cement type



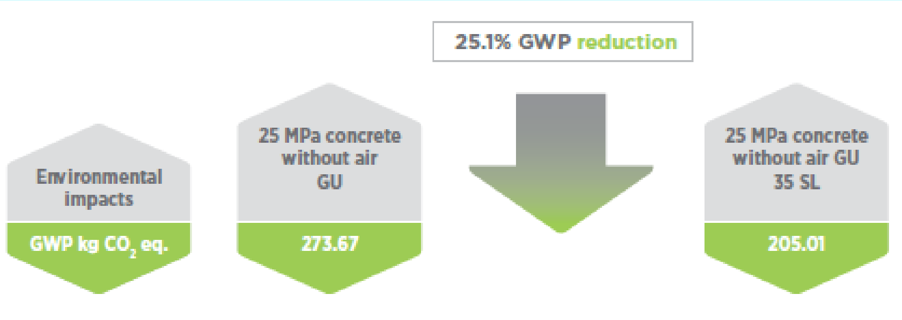


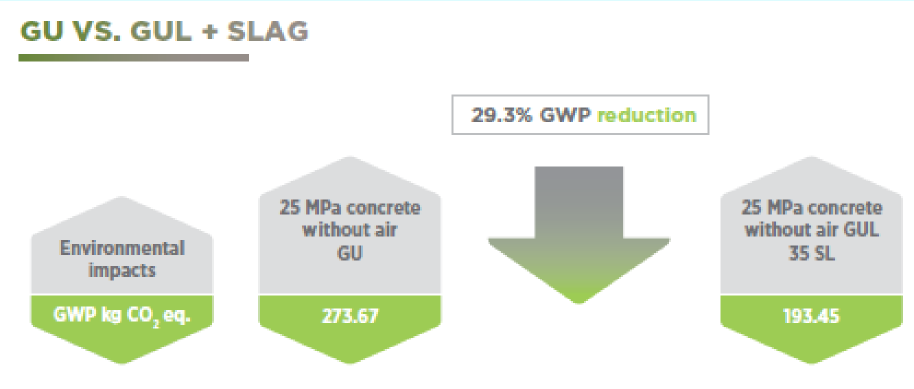
*Up to 10% reduction possible

Producing Low Carbon Concrete

Maximize the Use of Supplementary Cementitious Materials (SCMs)

- Cement Type & SCM usage can result in dramatic reductions





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Producing Low Carbon Concrete

Maximize the Use of Supplementary Cementing Materials (SCMs)

- Slag is the primary SCM in Ontario
- Fly Ash is used in Western Canada
- Silica Fume can also be used
- New & innovative products are coming to market

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Producing Low Carbon Concrete

Optimize Aggregates

- Larger Aggregate Size:
  - Lower paste content versus more challenging placement conditions
- Aggregate Gradation Optimization
- Recycled Concrete Aggregates

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Producing Low Carbon Concrete

Utilize Chemical Admixtures

- Water reduction
- Improved placeability
- Innovative performance and carbon reduction products

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Producing Low Carbon Concrete

- Communication & Evaluation
  - Schedule
  - Placement method
  - Strength requirements (do you need 28-day strength or is 56-day sufficient)
  - Special applications

- **Challenges**

  Cold weather concreting (Accelerated set & strength development)

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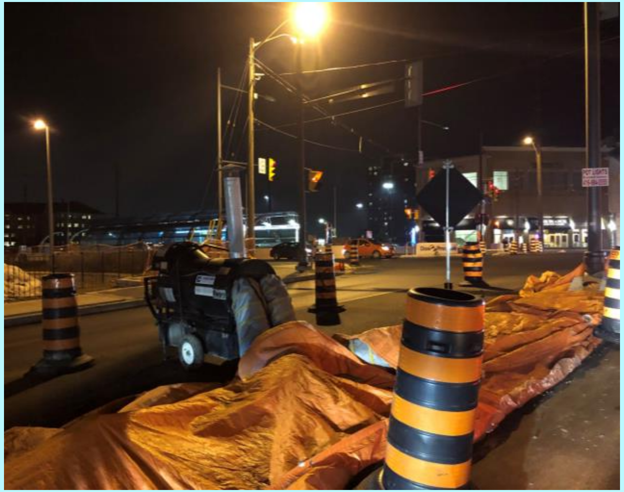
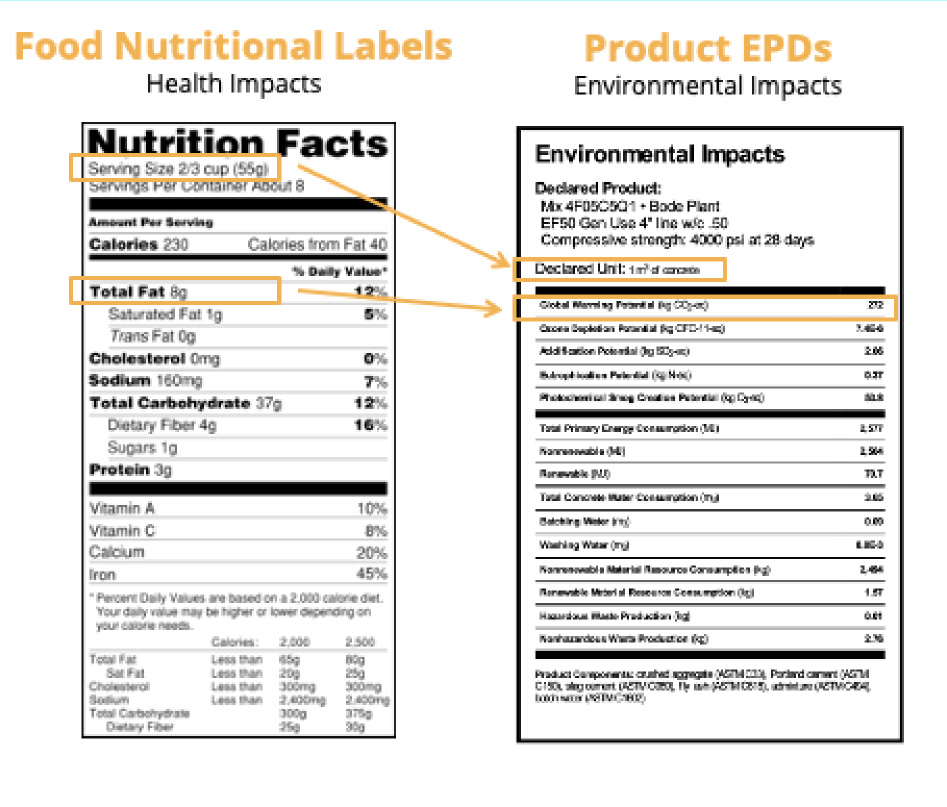


What are EPD’s ?

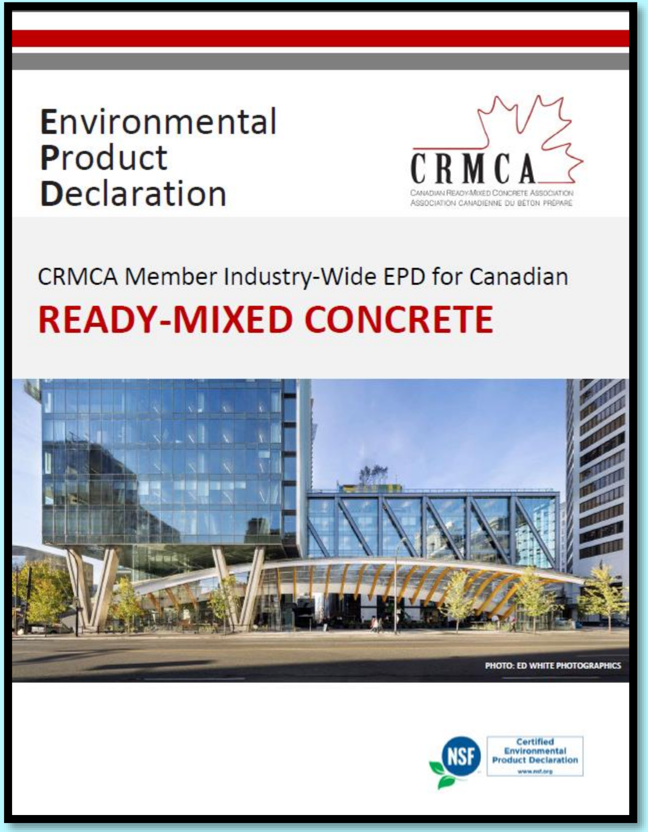

PAVE AHEAD
DURABLE. SUSTAINABLE. CONCRETE.
"EPDs
are Key to Concrete's Sustainable Future"

Environmental Product Declarations

- EPDs for concrete are much like nutrition labels for common foods
- EPDs outline the impact a certain concrete mix design has on the environment
- Most important metric is the **Global Warming Potential (GWP)** which is calculated in kg CO_2/m^3



CRMCA Industry-Wide EPD for Canadian Ready-Mixed Concrete (Expired January 2022)


Environmental Product Declaration

CRMCA
CANADIAN READY-MIXED CONCRETE ASSOCIATION
ASSOCIATION CANADIENNE DU BÉTON PRÉPARÉ

CRMCA Member Industry-Wide EPD for Canadian

READY-MIXED CONCRETE

PHOTO: ED WHITE PHOTOGRAPHICS

NSF Certified Environmental Product Declaration www.nsf.org

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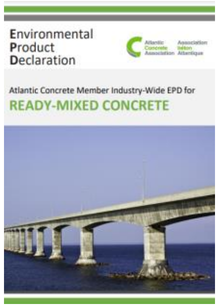
2022 CRMCA Industry-Average Regional EPDs Reports



- https://www.astm.org/products-services/certification/environmental-product-declarations/epd-pcr.html

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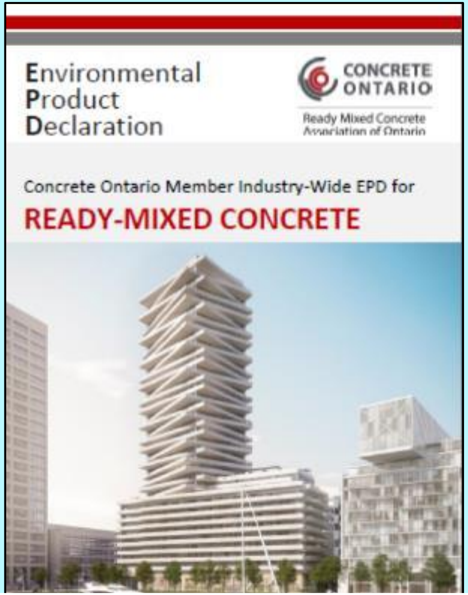
Concrete Ontario Member Industry-Wide EPD for Ready-Mixed Concrete (July 2022)



Building Life Cycle Information Modules																
Product stage			Construction Process stage		Use stage							End-of-life stage			
Raw Material supply	Transport	Manufacturing	Transport	Construction/Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	De-Construction/	Transport	Waste processing	Disposal
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4

Figure 1: Life cycle stage schematic – alpha-numeric designations as per NSF PCR 2021

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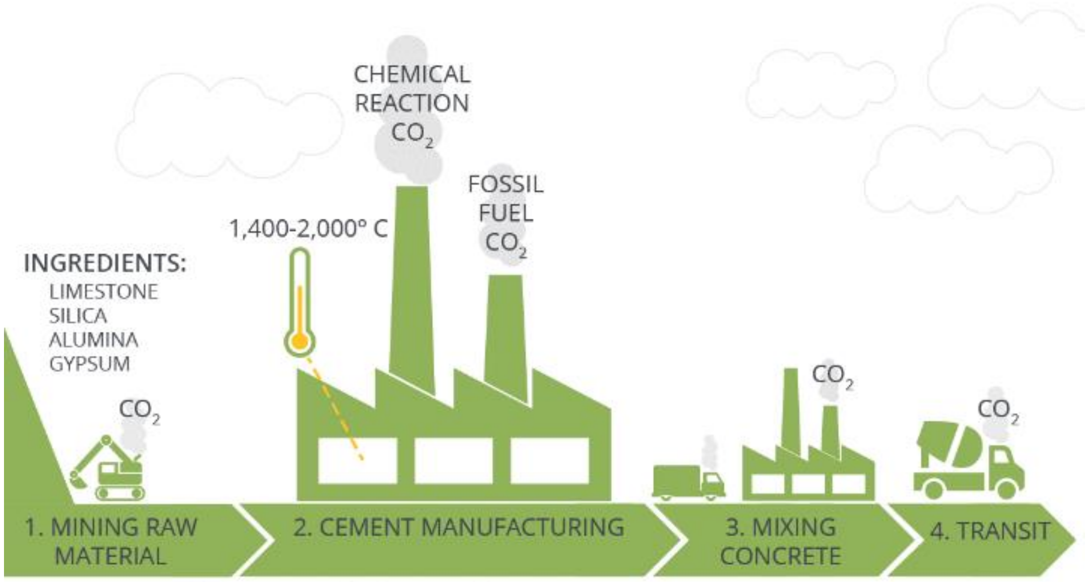
Cradle to Gate Analysis

2022 Concrete Ontario Report

Scope A1-A3



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Establishing Baselines is Critical for EPDs

Table 19. LCA Results 32 MPa concrete with air & 0.45 w/cm (C-2)

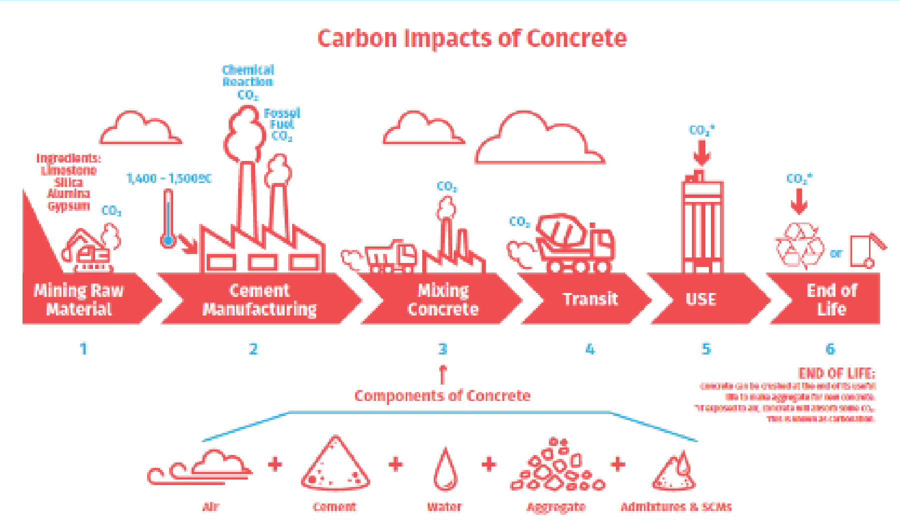
	Unit	Baseline 32 MPa concrete with air & 0.45 w/cm (C-2) GU 10 SL	32 MPa concrete with air & 0.45 w/cm (C-2) GU	32 MPa concrete with air & 0.45 w/cm (C-2) GU 15 SL	32 MPa concrete with air & 0.45 w/cm (C-2) GU 25 SL	32 MPa concrete with air & 0.45 w/cm (C-2) GU 35 SL	32 MPa concrete with air & 0.45 w/cm (C-2) GU 50 SL	32 MPa concrete with air & 0.45 w/cm (C-2) GUL	32 MPa concrete with air & 0.45 w/cm (C-2) GUL 15 SL	32 MPa concrete with air & 0.45 w/cm (C-2) GUL 25 SL	32 MPa concrete with air & 0.45 w/cm (C-2) GUL 35 SL	32 MPa concrete with air & 0.45 w/cm (C-2) GUL 50 SL
Environmental impacts												
GWP	kg CO_2 eq.	326.46	35[illegible].57	313.40	287.30	261.19	222.03	328.90	293.29	269.55	245.81	210.20
ODP	kg CFC-11 eq.	8.24E-06	8.12E-06	8.31E-06	8.43E-06	8.56E-06	8.74E-06	7.75E-06	8.00E-06	8.16E-06	8.32E-06	8.56E-06
EP	kg N eq.	0.25	0.27	0.25	0.24	0.23	0.21	0.25	0.23	0.23	0.22	0.20
AP	kg SO_2 eq.	1.50	1.54	1.48	1.44	1.40	1.34	1.46	1.41	1.38	1.35	1.30
POCP	kg O_3 eq.	24.91	25.12	24.81	24.61	24.40	24.10	24.03	23.89	23.79	23.70	23.56

Baselines are critical to set and achieve carbon reduction goals

CRMCA EPD Report Benchmark 2017	Ontario EPD Report Baseline 2022	% Reduction
25 MPa Industry Average Benchmark with air (6% SL, 4% FA) 304.52 $kgCO_2/m^3$	**Baseline 25 MPa concrete with air & 0.55 w/cm (F-2) GU 10 SL** 260.64 $kgCO_2/m^3$	**14.4**
30 MPa Industry Average Benchmark with air (6% SL, 4% FA) 349.68 $kgCO_2/m^3$	**Baseline 30 MPa concrete with air & 0.50 w/cm (F-1) GU 15 SL** 292.72 $kgCO_2/m^3$	**16.3**
35 MPa Industry Average Benchmark with air (6% SL, 4% FA) 417.05 $kgCO_2/m^3$	**Baseline 35 MPa concrete with air GU 15 SL** 334.49 $kgCO_2/m^3$	**19.8**
40 MPa Industry Average Benchmark with air (6% SL, 4% FA) 458.98 $kgCO_2/m^3$	**Baseline 40 MPa concrete with air GU 15 SL** 361.65 $kgCO_2/m^3$	**21.2**
45 MPa Industry Average Benchmark without air (6% SL, 4% FA) 426.33 $kgCO_2/m^3$	**Baseline 45 MPa concrete without air GU 15 SL** 349.88 $kgCO_2/m^3$	**17.9**

What are the Differences Between EPD Types?

- **Industry Average** – CRMCA Ontario / Manitoba Report
- **Type II** – Facility Specific
- **Type III** – Facility Specific & Third Party Verified



Treasury Board of
Canada Secretariat

Treasury Board of Canada Secretariat

Standard on Embodied Carbon in Construction

https://www.tbs-sct.canada.ca/pol/doc-eng.aspx?id=32742

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- Effective **December 31, 2022**, all federal projects budgeted at or above $10 million, using a minimum 100 m^3 of ready mixed concrete
- Disclosure of Type II or Type III EPDs
- **10% reduction from the total project GHG emissions** from ready mixed concrete, using the GWPs of the baseline mixes in the Ontario Regional Industry Average Environmental Product Declaration (EPD) for the strength class of each mix and the volume of mix placed
- Where specialized concrete mixes are required for **high early strength, high or ultra-high performance, and/or cold-weather applications, the baseline used for those mixes shall be 130% of the baseline mix** in the Ontario Regional Industry Average EPD for that strength class

Treasury Board of Canada Secretariat

Concrete Carbon Project Budget

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- Developing a concrete carbon project budget approach allows flexibility in the concrete mix designs used as a result of a demanding schedule and special applications

$$GHG\ reduction = CO2e\ Baseline - CO2e\ Project$$

Carbon dioxide equivalent (CO2e) Baseline: The emissions calculated by the volumes of all the mixes used in the project multiplied by their regional (Ontario) average GWP

CO2e Project: The emissions from the concrete used in the project calculated by the volumes of all the mixes used in the project multiplied by their GWP

$$\%\ GHG\ reduction = \frac{(GHG\ Reduction) \cdot 100}{CO2e\ Baseline}$$

Low Carbon Concrete – EPD Example

Concrete Apron Example

Example:
Mix: 32 MPa Class C-2
Volume: 5,000 m^3
Baseline: 326.46 kg CO_2/m^3
Concrete placed (GUL 25% SL): 269.55 kg CO_2/m^3

CO2e Baseline
5,000 m^3 x 326.46 kg CO_2/m^3 = 1,632 tonnes CO_2

CO2e Project
5,000 m^3 x 269.55 kg CO_2/m^3 = 1,348 tonnes CO_2

GHG Reduction: 1,632 – 1,348 = 284 tonnes CO_2

% GHG Reduction: **17.4%**

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Concrete Apron Example

Concrete Carbon Project Budget

<u>Example (Cold Weather):</u>

Mix: 32 MPa Class C-2

Volume: 5,000 m^3

Baseline: 326.46 **x 1.3** kg CO_2/m^3 = **424.40 CO_2/m^3**

Accelerated concrete placed (20MPa at 48 hours): 398.04 kg CO_2/m^3

CO2e Baseline

5,000 m^3 x 424.40 kg CO_2/m^3 = 2,122 tonnes CO_2

CO2e Project

5,000 m^3 x 398.04 kg CO_2/m^3 = 1,990 tonnes CO_2

GHG Reduction: 2,122 – 1,990 = 132 tonnes CO_2

% GHG Reduction: 6.2%

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Concrete Carbon Project Budget

Example (Full Project):
Mix: 32 MPa Class C-2
Volume: 5,000 m^3

% GHG Reduction: (17.4 + 6.2)/2 = 11.8%

Treasury Board GHG Spreadsheet

Ready-Mix Concrete Reporting Section (Enter each mix type provided on the project)

Ready-Mix Concrete on Project			Project Mix	Baseline GHG Calculations				GHG Calculations for Project Mixes				GHG Emissions Reduction	
Element of building or structure (for example, walls, foundation)	**Special Application: Yes/No** (required to be high early strength, high or ultra-high performance, or applied in cold weather conditions as per design specification s)	**Volume Reduction: Yes/No** where a volume of a mix is reduced, i.e. by increasing its compressive strength, without the addition of other	**Compressive Strength (MPa) @ 28 days**	**Life cycle assessment (LCA) results table number** (This example uses the ASTM International EPD for	**Baseline GWP (kg CO_2/m^3) per mix** (using equivalent compressive strength from the regional ASTM International EPD)	**Volume (m^3)**	**Baseline GHG emissions per mix (tonnes CO2)** based on the baseline GWP and volume	**EPD or mix design reference number for the mix provided** (from the supplier's EPD)	**GWP (kg CO_2/m^3) of the mix provided** (from the supplier's EPD)	**Adjusted Volume (m^3)** Note: only fill where "Yes" is selected for volume reduction	**GHG Emissions per mix Provided (tonnes CO_2)**	**GHG Emissions reduced from the baseline per mix Provided (tonnes CO_2)**	**Percentage reduction in GHG emissions per mix compared to the baseline**
Wall Foundations	Yes	No	45	12	349.88	230.0	104.61	#####	401.2		92.28	12.34	11.8%
Column Foundations	Yes	No	60	15	361.25	21.5	10.10	#####	416.54		8.96	1.14	11.3%
Structural Slabs-on-Grad	No	No	35	10	295.46	2331.0	688.72	#####	272.45		635.08	53.64	7.8%
Subgrade Enclosure Wall	No	No	35	10	295.46	207.5	61.31	#####	288.16		59.79	1.51	2.5%
Floor Decks, Slabs, and T	No	No	35	10	295.46	2276.0	672.47	#####	254.95		580.27	92.20	13.7%
Floor Structural Frame	No	Yes	45	12	349.88	118.0	41.29	#####	313.88	112.0	35.15	6.13	14.9%
Floor Decks, Slabs, and T	No	No	35	10	295.46	2034.0	600.97	#####	257.71		524.18	76.78	12.8%
Floor Structural Frame	No	Yes	45	12	349.88	118.0	41.29	#####	313.88	112.0	35.15	6.13	14.9%
Floor Decks, Slabs, and T	No	No	35	10	295.46	273.5	80.81	#####	265.4		72.59	8.22	10.2%
Stair Construction	No	No	30	9	264.38	15.5	4.10	#####	249.04		3.86	0.24	5.8%
Roof Decks, Slabs, and S	No	No	35	10	295.46	1852.0	547.19	#####	258.5		478.74	68.45	12.5%
Pedestrian Pavement	No	No	25	8	264.94	414.0	109.69	#####	224.67		93.01	16.67	15.2%
Exterior Steps and Ramp	No	No	30	9	264.38	128.0	33.84	#####	230.42		29.49	4.35	12.8%
Project Totals	N/A		N/A		N/A	10019.0	#REF!	N/A	N/A	N/A	#####	347.81	11.2%

Reduction in GHG emissions related to the embodied carbon of ready-mix concrete supplied to the project (tonnes)	348
Percentage reduction in GHG emissions related to the embodied carbon of ready-mix concrete supplied to the project	11.2%

Concrete Ontario GHG Spreadsheet

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Insert Row | Delete Row | Back to Step 1 | Back to Instructions | View Ontario EPD Report Values | View Ontario EPD Baseline Values

Concrete Mix Design Description or Mix #	Volume Placed (m3)	Ontario Industry-Average EPD Baseline Mix	Baseline GWP (kgCO2/m3)	Special Application (High-early strength, HPC/UHPC or cold-weather)	Updated Baseline GWP (kgCO2/m3) (30% increase)	Ontario Industr
Mix #4	43.0	Baseline 32MPa concrete with air & 0.45 w/cm (C-2) GU 10 SL	326.46	No	N/A	
Mix #3	350.0	Baseline 30MPa concrete with air & 0.50 w/cm (F-1) GU 15 SL	292.72	Yes	380.53	
Mix #2	153.0	Baseline 35MPa concrete with air & 0.40 w/cm (C-1) GU 25 SL	313.07	No	N/A	
Mix #1	20.0	Baseline 32MPa concrete with air & 0.45 w/cm (C-2) GU 10 SL	326.46	Yes	424.40	
Total	**566.0**					

CONCRETECARBON:
Guideline for Specifying Low Carbon Ready Mixed Concrete in Ontario (November 2022)

https://www.rmcao.org/wp-content/uploads/2022/10/ConcreteCarbon-November-2022-Final.pdf

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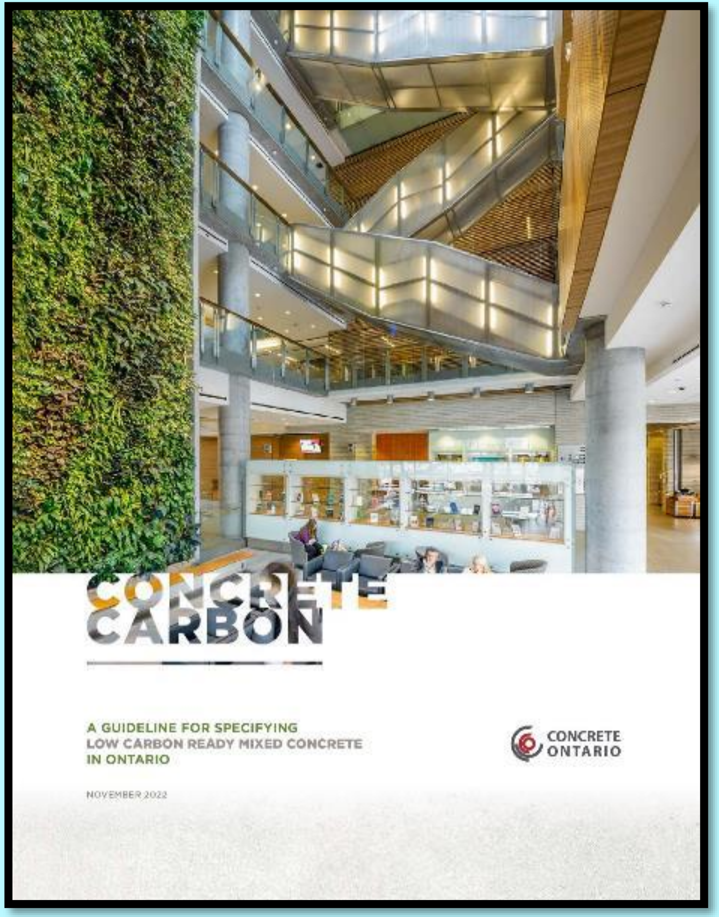

Summary

- Low Carbon Concrete is the sustainable future
- Performance-based specifications are critical
- Communication between all parties is critical
- Concrete carbon budgeting is key
- Carbon accounting will be a challenge
- Low carbon concrete is an evolving landscape and as carbon budgeting projects are completed, further information will become available
- Concrete Canada and CAC provide low carbon concrete presentations and complimentary feedback on specifications

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Thank you!

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Questions?

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