Low Carbon Concrete in Ontario

Webinar

September 20, 2022

CONCRETE ONTARIO | Ready Mixed Concrete Association of Ontario

Presenters

Bart Kanters, P.Eng., MBA | President

Alen Keri, P.Eng. | Director of Technical Services

Housekeeping

- Approximately a 45-minute webinar with Q & A at the end
- All participants are muted
- Questions? Use the GoToWebinar ‘Questions’ Pane
- Webinar is being recorded and will be posted on the Concrete Ontario website along with a PDF copy of the presentation.
  - https://www.rmcao.org/publications/webinar-presentations/
- Follow-up email will be sent tomorrow to all participants and absentees with access information

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Agenda

- What are EPDs?
- History of EPDs in Canada
- Ontario Industry-Average EPD Report
  - What is the scope?
  - How was the plant data collected?
  - How were the mix designs established?
- Carbon Reduction Goals
  - Concrete Carbon Project Budget
  - Challenges
- CONCRETE**CARBON**: Guideline for Specifying

  Low Carbon Concrete in Ontario Preview

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Environmental Product Declarations

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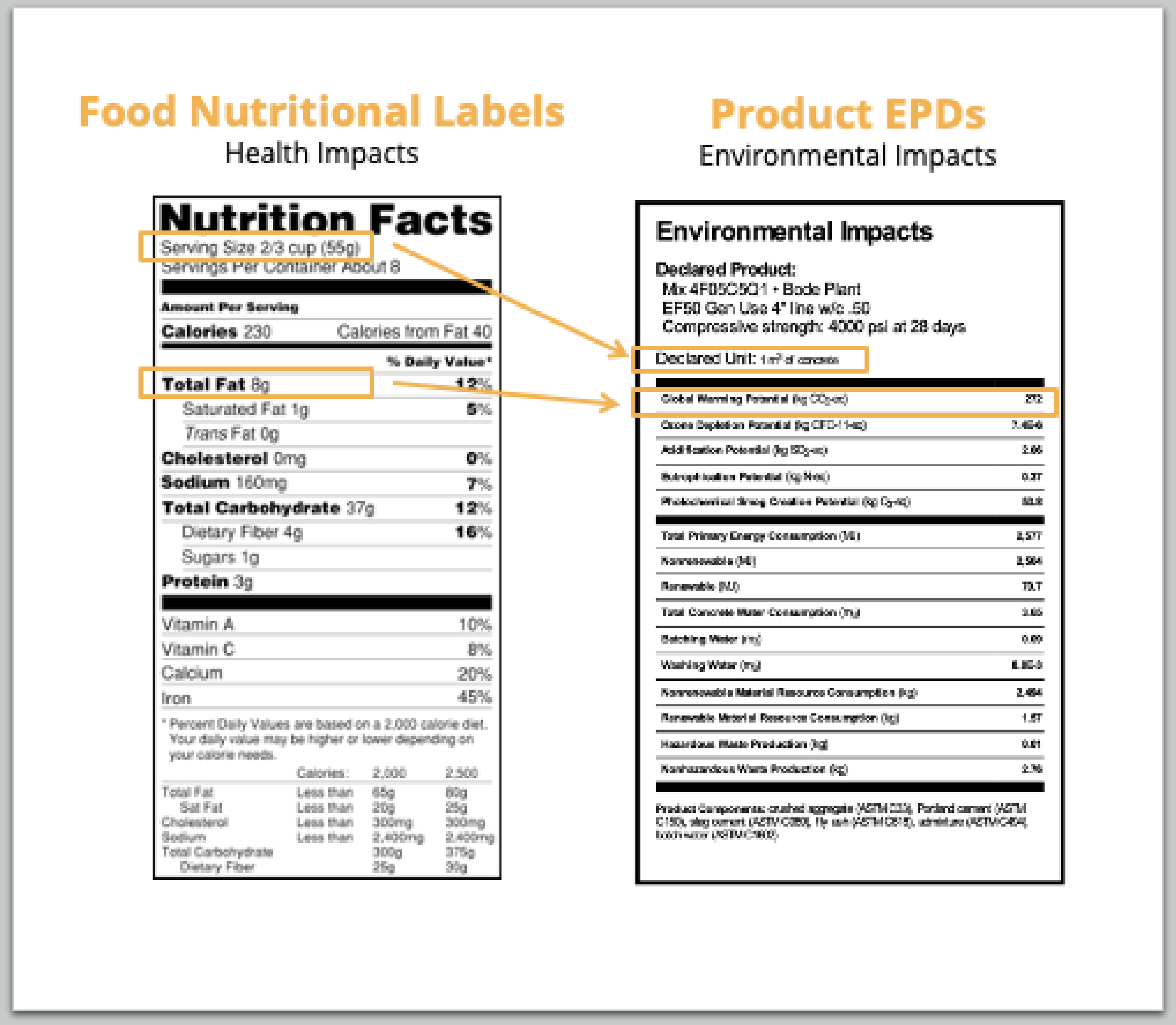
Environmental Product Declarations

- 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



2017 CRMCA Report
Overview

- Represents data for an average ready-mix concrete plant in Canada
- 25MPa – 60MPa
- Benchmarks set at 6% Slag and 4% Fly Ash
- Expired on January 6, 2022

2022 CRMCA Industry-Average EPD Regional Reports

- Fully funded by the National Research Council of Canada (NRC) in conjunction with the Canadian Ready-Mixed Concrete Association (CRMCA)
- Developed by the Athena Sustainable Materials Institute and third-party verified by ASTM International
- **All 7 regional reports are now available on ASTM's website**
- https://www.astm.org/products-services/certification/environmental-product-declarations/epd-pcr.html

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2022 Concrete Ontario Report
Overview

- Represents data for an average ready-mix concrete plant in Ontario
- **20MPa – 70MPa**
- Baselines set according to average Ontario cement content values and SCM usage in 2021
- Valid for 5 years
- Right of usage in Ontario is for all active Concrete Ontario members

2022 Concrete Ontario Report
Scope A1-A3

A1 - Raw Material Supply: Includes all upstream processes related to extraction, handling, and processing of the raw materials and intermediate component products as well as fuels used in the production of concrete. Component products include cement, supplementary cementitious materials, aggregate (coarse and fine), water, admixtures and other materials or chemicals used in concrete mixtures.

A2 - Transportation: Accounts for the transportation of all input materials and fuels from the supplier to the gate of the concrete plant.

A3 - Manufacturing (Core Processes): Includes all core processes and the energy and water used to store, move, batch, and mix the concrete and operate the concrete plant as well as the transportation and processing of wastes from these core processes.

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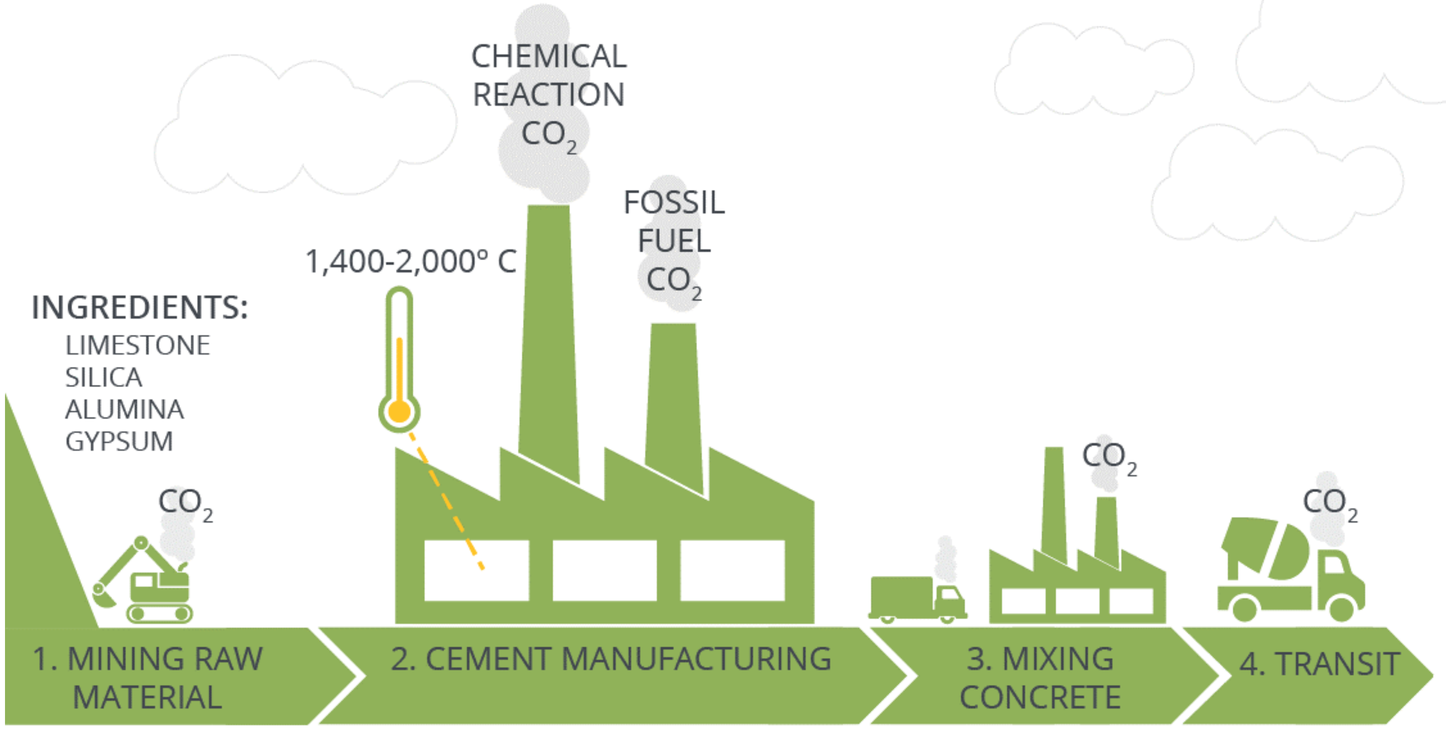
Scope A1-A3



A1 A2 A3

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2022 Concrete Ontario Report

Plant Survey

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2022 Concrete Ontario Report
Plant Survey

- A representative sample of Concrete Ontario member facilities were selected **based on technical attributes, production scale, and geographic location.**
- In total, **80 facilities** operated by Concrete Ontario member companies completed LCI data collection questionnaires **representing over 30% of all Concrete Ontario member facilities.**
- Data reflects the 2020 production season

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2022 Concrete Ontario Report
Plant Survey

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Plant Information - Annual Production and Usage

Concrete Production

Total Concrete Production (m3)

Batch Waste (%)

Purchased Energy

Purchased Electricity - Used at Plant (kWh)

Purchased Electricity From Green Grid

Site Generated Renewable Electricity (solar, wind) - Used at Plant

Site Generated Bio Based Electricity (wood waste) - Used at Plant

Site Generated Renewable Electricity (solar, wind) - Sold

Site Generated Bio Based Electricity (wood waste) - Sold

Natural Gas - Used at Plant (m3)

Secondary Fuels - Liquid (l)

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Plant Survey

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Secondary Fuels - Solid

Fuel Oil - Used at Plant (l)

Diesel - Used at Plant (l)

Gasoline - Used at Plant (l)

LPG (Liquified Propane Gas) - Used at Plant (l)

Transit Mix Only - Diesel - Used in Fleet (l)

Natural Gas - Used in Fleet

Annual Plant Consumables

Road Dust Control Chemicals (e.g. chlorides) (l)

Oil and Lubricants (l)

Grease (l)

Water Use

Total Water Use (l)

Percentage of Batch Water That Is Recycled Wash Water (%)

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Plant Survey

Waste Generated

Hazardous Solid Waste (kg)

Non-Hazardous Solid Waste (kg)

Air Emissions (if tracked)

Particulates, PM-2.5 (kg)

Particulates, PM-10 (kg)

Particulates, total (kg)

Lead (kg)

Hg (kg)

CO (kg)

NOx (kg)

SOx (kg)

VOC (kg)

Water Emissions (if tracked)

Total Suspended Solids (kg)

Total Dissolved Solids (kg)

Biological Oxygen Demand (BOD) (kg)

Chemical Oxygen Demand (COD)

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Mix Designs

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2022 Concrete Ontario Report
Mix Designs

- **23 mix designs** based on 2021 production cement contents were chosen to represent the Ontario ready-mix industry
- Mix designs are **fully representative of the OBC and CSA A23.1 Tables 1 and 2 – Exposure Classes** performance requirements
- Slag replacement levels between **0-50%**
- Baselines were set based on average Ontario slag usage in 2021 for each mix design (Type GU as base cement)

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Table 18. LCA Results 30 MPa concrete with air & 0.50 w/cm (F-1)	Unit	Baseline 30 MPa concrete with air & 0.50 w/cm (F-1) GU 15 SL	30 MPa concrete with air & 0.50 w/cm (F-1) GU	30 MPa concrete with air & 0.50 w/cm (F-1) GU 15 SL	30 MPa concrete with air & 0.50 w/cm (F-1) GU 25 SL	30 MPa concrete with air & 0.50 w/cm (F-1) GU 35 SL	30 MPa concrete with air & 0.50 w/cm (F-1) GU 50 SL	30 MPa concrete with air & 0.50 w/cm (F-1) GUL	30 MPa concrete with air & 0.50 w/cm (F-1) GUL 15 SL	30 MPa concrete with air & 0.50 w/cm (F-1) GUL 25 SL	30 MPa concrete with air & 0.50 w/cm (F-1) GUL 35 SL	30 MPa concrete with air & 0.50 w/cm (F-1) GUL 50 SL
Environmental impacts												
GWP	kg CO_2 eq.	292.72	329.02	292.72	268.52	244.32	208.02	307.08	274.07	252.07	230.06	197.05
ODP	kg CFC-11 eq.	7.74E-06	7.57E-06	7.74E-06	7.86E-06	7.97E-06	8.15E-06	7.23E-06	7.45E-06	7.60E-06	7.75E-06	7.98E-06
EP	kg N eq.	0.23	0.25	0.23	0.22	0.21	0.20	0.23	0.22	0.21	0.20	0.19
AP	kg SO_2 eq.	1.40	1.45	1.40	1.36	1.32	1.26	1.38	1.33	1.30	1.27	1.23
POCP	kg O_3 eq.	23.58	23.86	23.58	23.39	23.20	22.92	22.85	22.72	22.63	22.55	22.42
Use of primary resources												
RPR_E	MJ, NCV	82.80	91.24	82.80	77.18	71.56	63.13	90.98	82.59	76.99	71.40	63.00
RPR_M	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$NRPR_E$	MJ, NCV	1798.64	1865.83	1798.64	1753.84	1709.04	1641.85	1765.03	1712.95	1678.24	1643.52	1591.45
$NRPR_M$	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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OBC House walls

20 MPa concrete with air & 0.70 w/cm

Low: 150.22 kg CO_2/m^3
High: 244.44 kg CO_2/m^3

Baseline: 227.16 kg CO_2/m^3

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Class F-1 - Pool decks, patios, tennis courts, freshwater pools, and freshwater control structures

30 MPa concrete with air & 0.50 w/cm (F-1)

Low: 197.05 kg CO_2/m^3
High: 329.02 kg CO_2/m^3

Baseline: 292.72 kg CO_2/m^3

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Class C-2 - Garage floors, porches, steps, pavements, sidewalks, curbs, and gutters

32 MPa concrete with air & 0.45 w/cm (C-2)

Low: 210.20 kg CO_2/m^3
High: 352.57 kg CO_2/m^3

Baseline: 326.46 kg CO_2/m^3

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Class C-1 - Bridge decks, parking decks and ramps

35 MPa concrete with air & 0.40 w/cm (C-1)

Low: 228.35 kg CO_2/m^3
High: 313.07 kg CO_2/m^3

Baseline: 313.07 kg CO_2/m^3
RCP requirement: <1500 coulombs within 91 days (Min. 25% slag)

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**

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2022 - 2027 % Reductions?
Cement industry innovations
Complete switchover to Type GUL

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Carbon Reduction Goals

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Element	Compressive Strength (MPa) 28 days U.N.O.	Class of exposure (CSA A23.1 Table 1 & 2)	Maximum water-to-cementitious materials ratio	Nominal maximum sizes of coarse aggregate (mm)	Air content category (CSA A23.1 Table 2)	Range in air content (%) (CSA A23.1 Table 4)	Ontario Industry-Average EPD Baseline Mix GWP ($kgCO_2/m^3$)
Footings	30 MPa (56 days)	N	--	20	--	--	264.38
Slab on grade (interior)	25 MPa	N-CF	0.55	20	--	--	264.94
Exterior columns (exposed)	25 MPa	F-2	0.55	20	2	4-7	260.64
Slab on grade (exterior)	32 MPa	C-2	0.45	20	1	5-8	326.46
Foundation walls (exposed)	30 MPa	F-1	0.50	20	1	5-8	334.49
Retaining/Foundation walls/shear walls (exposed)	35 MPa	F-2	0.55	40	2	3-6	334.49
Shear walls (not exposed)	35 MPa	N	--	20	--	--	295.46
Columns (exposed)	35 MPa (56 days)	C-1	0.40	20	1	5-8	313.07
Architectural columns (exposed) SCC	35 MPa (56 days)	C-1	0.40	10	1	6-9	377.33
Topping on steel deck	25 MPa	N	--	10	--	--	254.05
Mechanical housekeeping pads	20 MPa	N	--	20	--	--	220.29

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Setting Carbon Reduction Goals

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- Using Ontario Industry-Average EPD Baseline Mix GWP values for carbon reduction goals is highly encouraged
- However, since these values are absolute values, their use is only practical for concrete that is poured in favourable weather using standard placement methods
- **Challenges:**
  - Cold weather concreting (Accelerated set & strength development)
  - Special applications (SCC, shotcrete, etc.)
  - Project schedule is vital
- Carbon accounting must be more flexible

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Concrete Carbon Project Budget

- 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

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

CO2e Benchmark represents the emissions calculated by the anticipated volumes of all the mixes used on the project multiplied by their respective Global Warming Potentials (GWPs) of the Ontario Industry-Average EPD Baselines

CO2e Project represents the emissions from the concrete placed on the project calculated by the volumes of all the mixes used on the project multiplied by their actual Global Warming Potential (GWP)

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

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Example

Class F-1 - Pool deck

30 MPa concrete with air & 0.50 w/cm (F-1)

Low: 197.05 kg CO_2/m^3
High: 329.02 kg CO_2/m^3

Baseline: 292.72 kg CO_2/m^3

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Concrete Carbon Project Budget

<u>Example:</u>
Mix: 30 MPa Class F-1
Volume: 9 m^3
Baseline: 292.72 kg CO_2/m^3
Concrete placed: 230.06 kg CO_2/m^3

CO2e Benchmark
9 m^3 x 292.72 kg CO_2/m^3 = 2.6 tonnes CO_2

CO2e Project
9 m^3 x 230.06 kg CO_2/m^3 = 2.1 tonnes CO_2

GHG Reduction: 2.6 – 2.1 = 0.5 tonnes CO_2

% GHG Reduction: 19.2%

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Challenges

Cold weather concreting (Accelerated set & strength development)

Challenges

Cold weather concreting (Accelerated set & strength development)

Cold Weather Concreting

- When there is a probability of the air temperature falling below 5°C within 24h of placing (as forecast by the nearest official meteorological office) (CSA A23.1)

Problems

- Additional protection and curing challenges
- Negative project schedule impact

Solutions

- Set accelerated mix designs
- Strength accelerated mix designs

Challenges

Special Applications (SCC, Shotcrete, etc.)

Holocaust Monument – Ottawa, ON

Self consolidating concrete (SCC)

Challenges

Special Applications (SCC, Shotcrete, etc.)

- **Architectural concrete** not only needs to meet the typical performance criteria of standard concrete but is also distinguished by having an aesthetic requirement

- Specialty concretes are critical in achieving architectural concrete and in allowing the contractor to maintain a reasonable project schedule

- Characteristics such as superior ease of placement and workability, reduced labour and superior performance for both strength and durability are all associated with special applications such as SCC

Impact of cold weather concreting and special applications on a carbon budget

If all available low carbon raw materials are already being used, options for the ready-mix producer include:

- Increasing the amount of Type GU or GUL used
- Reducing the amount of SCMs (Slag in Ontario) in the mix design, but not to the exclusion of durability performance specifications
- Incorporating the use of specialty admixtures

CONCRETECARBON:
Guideline for Specifying Low Carbon Concrete in Ontario
(Fall 2022)

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CONCRETECARBON: Guideline for Specifying Low Carbon Concrete in Ontario

- Comprehensive look at specifying low carbon concrete through a performance-based specification
- Compilation of low carbon concrete document resources and specifications
- Step-by-step process to set a carbon budget and the overall carbon accounting procedure
- Summary of impact of cold weather concreting and special applications on a carbon budget

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THE MET
Condo Case Study

35 Story Condo
~30,000 m^3 of concrete
~15,000 m^3 accelerated concrete
2016-2019

The Met – Vaughan, ON
Image credit: Plaza/Berkley

Questions?

Specifying Low Carbon Concrete in Ontario

Webinar

October 26, 2022
10:00-11:00 am

Thank you.

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