Concrete & Cement Sustainability Initiatives

Jasper Place Library, Edmonton, AB. Architect: HCMA Architecture + Design

CONCRETE ONTARIO | Ready Mixed Concrete Association of Ontario

CONCRETE | Build for life

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.

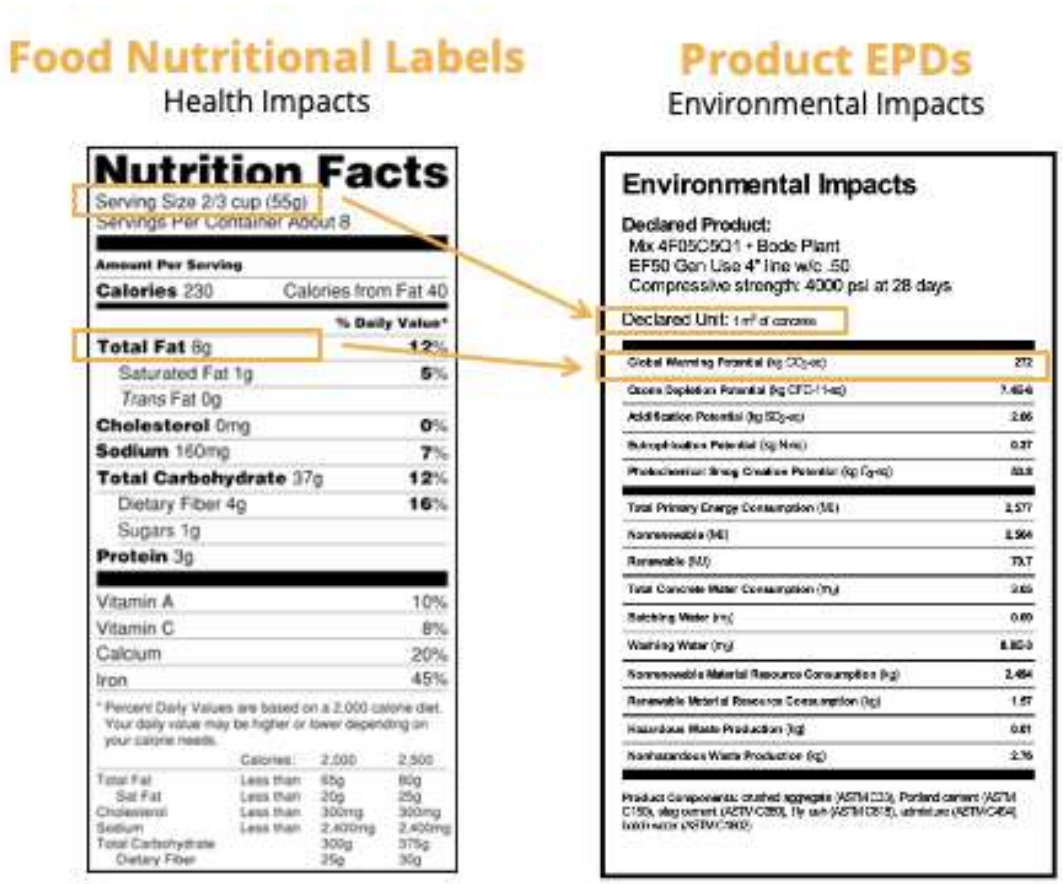
- To employ low carbon concrete:

  - Use available lower carbon impact materials
  - Mix design optimization (Admixtures)
  - Carbon mineralization technology
  - Tools to quantify the carbon impact (EPDs)
  - Project carbon budgeting

Environmental Product Declarations (EPDs)

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



Evolution of Low Carbon Concrete in Ontario

1 **January 2017**
CRMCA Industry-Average EPD Report released

2 **October 2021**
First Ontario low carbon concrete specification

3 **January 2022**
CRMCA report expires

4 **July 2022**
Ontario Industry-Average EPD report released

5 **October 2022**
ConcreteCarbon Guideline released

6 **November 2022**
Roadmap to Net-Zero Carbon Concrete

7 **November 2022**
ConcreteCarbon Guideline updated

8 **2030**
Carbon reduction goals

9 **2050**
Net-zero carbon concrete

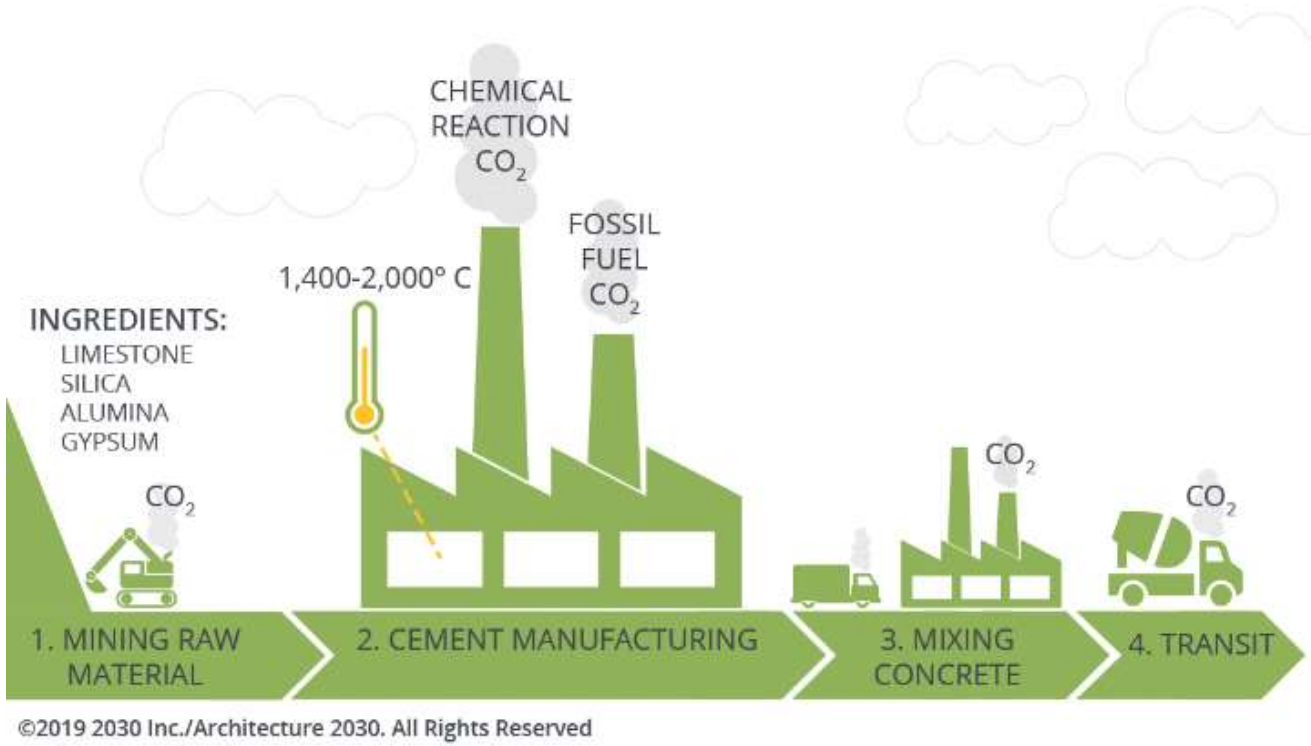
10

Concrete Ontario Member Industry-Wide EPD for Ready-Mixed Concrete

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

2022 Concrete Ontario Report Scope A1-A3



A1 **A2** **A3**

2022 Concrete Ontario Report
Mix Designs

2022 Concrete Ontario Report
Mix Designs

- **23 mix designs** 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 cement content and slag usage in 2021 for each mix design (Type GU as base cement)

2022 Concrete Ontario Report
Mix Designs

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

Baselines are critical to set and achieve carbon reduction goals

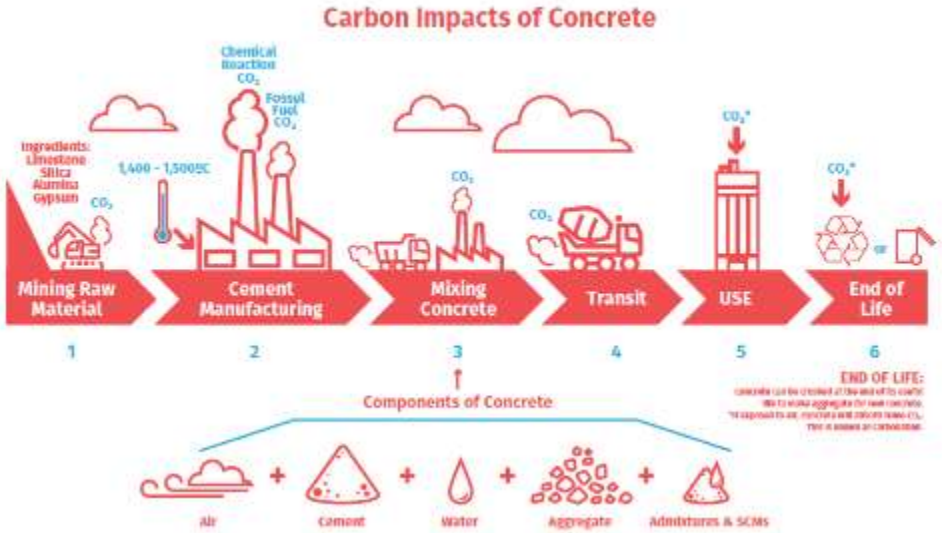
GWP Reductions from 2017 to 2022

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**

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

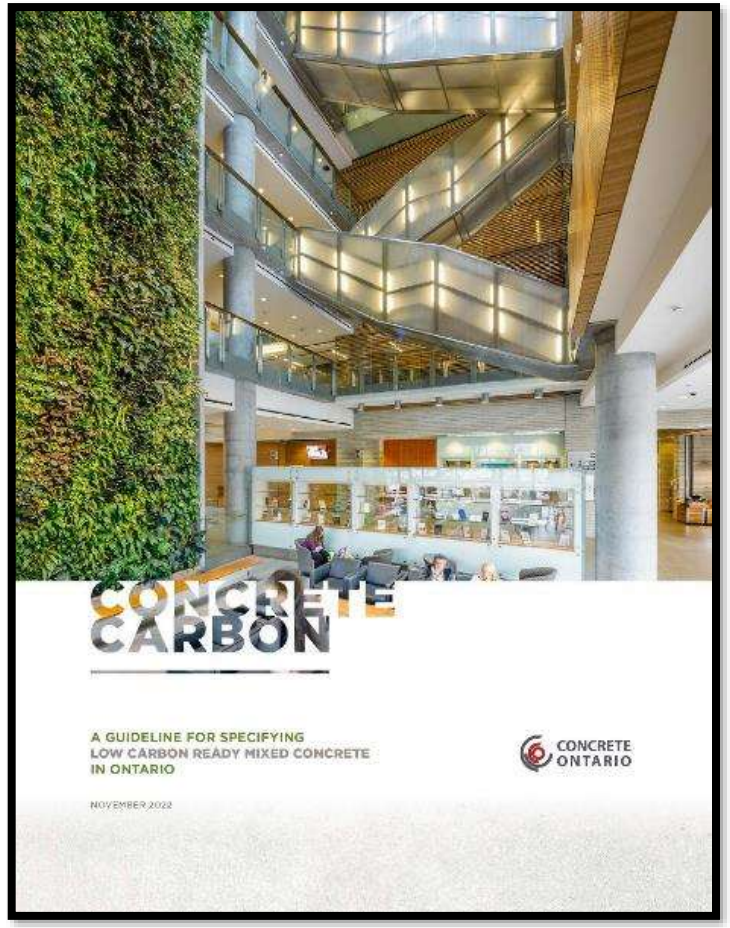
What are the Differences Between EPD Types?

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



NRMCA CERTIFIED EPD

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



So How Do I Produce Low Carbon Concrete?

Concrete Plant Factors:

- Raw Materials
- Raw Material Transportation
- Diesel Fuel Usage
- Natural Gas / Fuel Oil Usage
- Electricity

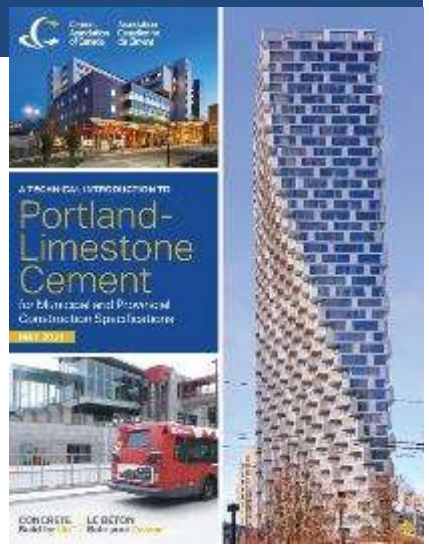
Raw Materials (kg CO_2/tonne):

- **GU Cement** = 880
- **GUL Cement** = 780
- **Slag** = 150
- **Aggregates** = 30
- **Fly Ash** = 10
- **Admixtures** = 1
- **Water** = 1

Producing Low Carbon Concrete

Evaluating all your Raw Materials

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

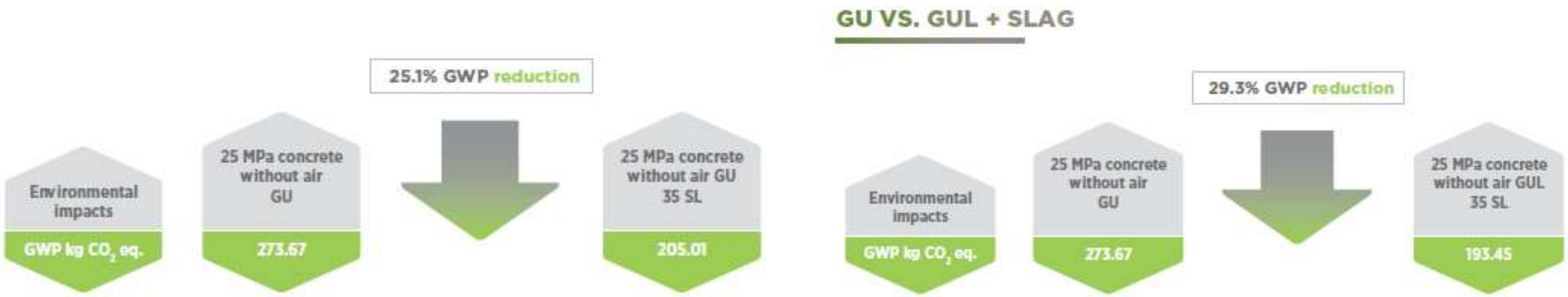


***Up to 10% reduction possible**

Producing Low Carbon Concrete

Maximize the Use of Supplementary Cementitious Materials (SCMs)

- Cement Type & SCM usage can result in dramatic reductions



Producing Low Carbon Concrete

Maximize the Use of Supplementary Cementing Materials (SCMs)

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

Producing Low Carbon Concrete

Optimize Aggregates

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

Producing Low Carbon Concrete

Utilize Chemical Admixtures

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

Specifying Low Carbon Ready Mixed Concrete in Ontario

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.

Performance-Based Specifications

Two Options in CSA A23.1/.2

Performance-Based Specifications

CSA A23.1 Table 5 – Owner Responsibilities

- Exposure Class
- Strength at Age (e.g., 35 MPa at 56 days)
- Required durability criteria (e.g., Maximum 0.40 w/cm, Class C-1)
- Additional criteria for durability (AVS, RCP, Shrinkage Limits, etc.)
- Architectural Requirements (e.g., Colour, surface finish, etc.)
- Pre-qualification or verification criteria (i.e., Low Permeability, Low Shrinkage, etc.)
- Any other properties that might be required to meet the owner's performance criteria

What Does This Mean for the Concrete Producer?

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

Producing Low Carbon Concrete

Communication & Evaluation

- Schedule
- Placement method
- Special applications

Challenges For the Concrete Producer

- Specifications
- Weather Impacts
- Contractor Requirements
- Field Testing Variability
- Raw Material Availability

Thank you!