Specifying Low Carbon Ready Mixed Concrete in Ontario

Webinar

October 26, 2022

CONCRETE ONTARIO | Ready Mixed Concrete Association of Ontario

Presenters

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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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Attendees should be familiar with the following

- Embodied Carbon
- What are EPDs?
- Ontario Industry-Average EPD Report

- https://www.rmcao.org/category/webinar-presentations/

Agenda

- What is Low Carbon Concrete?
- Specifying Low Carbon Ready Mixed Concrete in Ontario
  - Performance-based Specifications
  - Concrete Raw Materials
  - Early Strength Development Concrete
- Concrete Carbon Project Budget
- Condo Case Study

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

Available for download in the Handouts section

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What is Low Carbon Concrete?

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What is Low Carbon Concrete?

- Concrete is a low carbon material compared to many other manufactured goods
- It is **locally and responsibly sourced**
- Used for its **structural performance, durability, versatility, and needed climate-change resiliency**.
- Through developing concrete technology and combined with the transparency afforded by EPDs it will allow the designer to monitor, control, and optimize the embodied carbon content of their designs.

What is Low Carbon Concrete?

- Low carbon concrete refers to concrete produced with a **lower carbon footprint** than traditional mix designs using baseline technology, while still meeting all relevant performance requirements.
- To employ low carbon concrete, specifiers, contractors, and ready mixed producers should work together to use available lower carbon impact materials and tools to quantify and reduce the carbon impact of the ready mixed concrete.

Specifying Low Carbon Ready Mixed Concrete in Ontario

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Specifying Ready Mixed Concrete in Ontario

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Following aspects are vital:

1. Qualification/Certification system for concrete production facilities (e.g. Concrete Ontario mandatory **ECO Certification**)
2. Designer defines **performance requirements** for the different concrete elements in the structure
3. **Producer and contractor partner** to ensure optimal concrete mixture is designed, delivered, and installed
4. **Submittal and documentation** of performance-based concrete mixes, delivery rates, traffic flows, washout areas, environmental and safety concerns, inspection and testing requirements, acceptance and rejection criteria, etc.
5. **Quality assurance testing** for acceptance of concrete
6. **Clear responsibilities** laid out for what to do in case of an abnormality

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.

Performance-Based Specifications

CSA A23.1 Table 5 – Owner Responsibilities (Must specify)

1. **Strength at Age** (e.g., 35 MPa at 56 days)
2. **Required durability criteria**, including class of exposure (e.g., Maximum 0.40 w/cm, Class C-1)
3. **Additional criteria for durability**
4. **Volume Stability**
5. **Architectural Requirements** (e.g., Colour, surface finish, etc.)
6. **Sustainability** (e.g., Maximum Global Warming Potential limits in $kg \cdot CO_2 /m^3$)
7. **Pre-qualification or verification criteria** (i.e., Low Permeability, Low Shrinkage, etc.)
8. **Quality management requirements**
9. Whether the concrete supplier shall meet **certification requirements** of concrete industry certification programs (i.e., Plant and truck certification according to the RMCAO)
10. **Any other properties** that might be required to meet the owner's performance criteria

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Producing Low Carbon Concrete

- Communication & Evaluation

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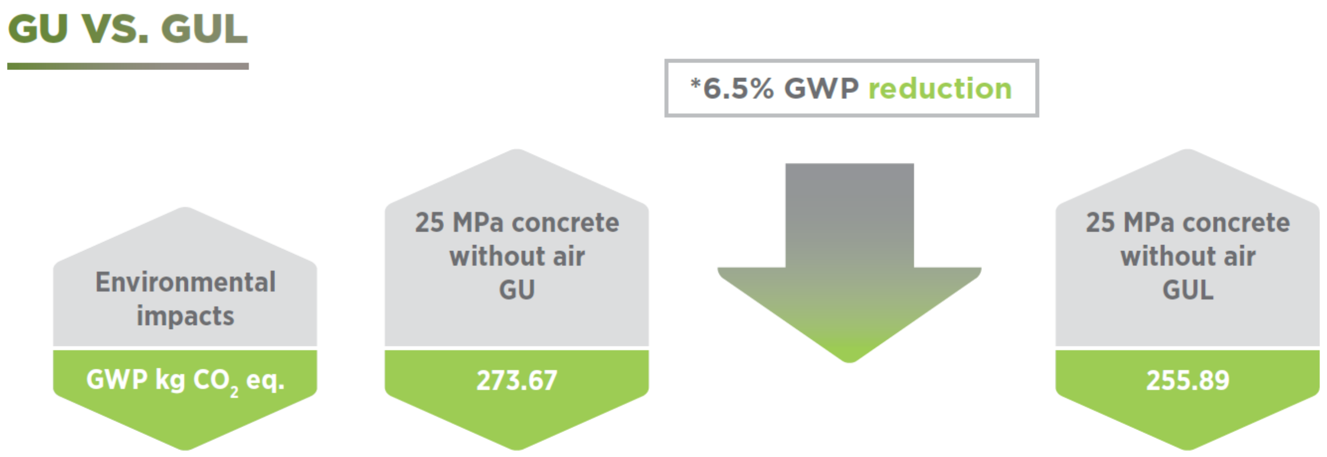
Producing Low Carbon Concrete

Evaluating all your Raw Materials

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



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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

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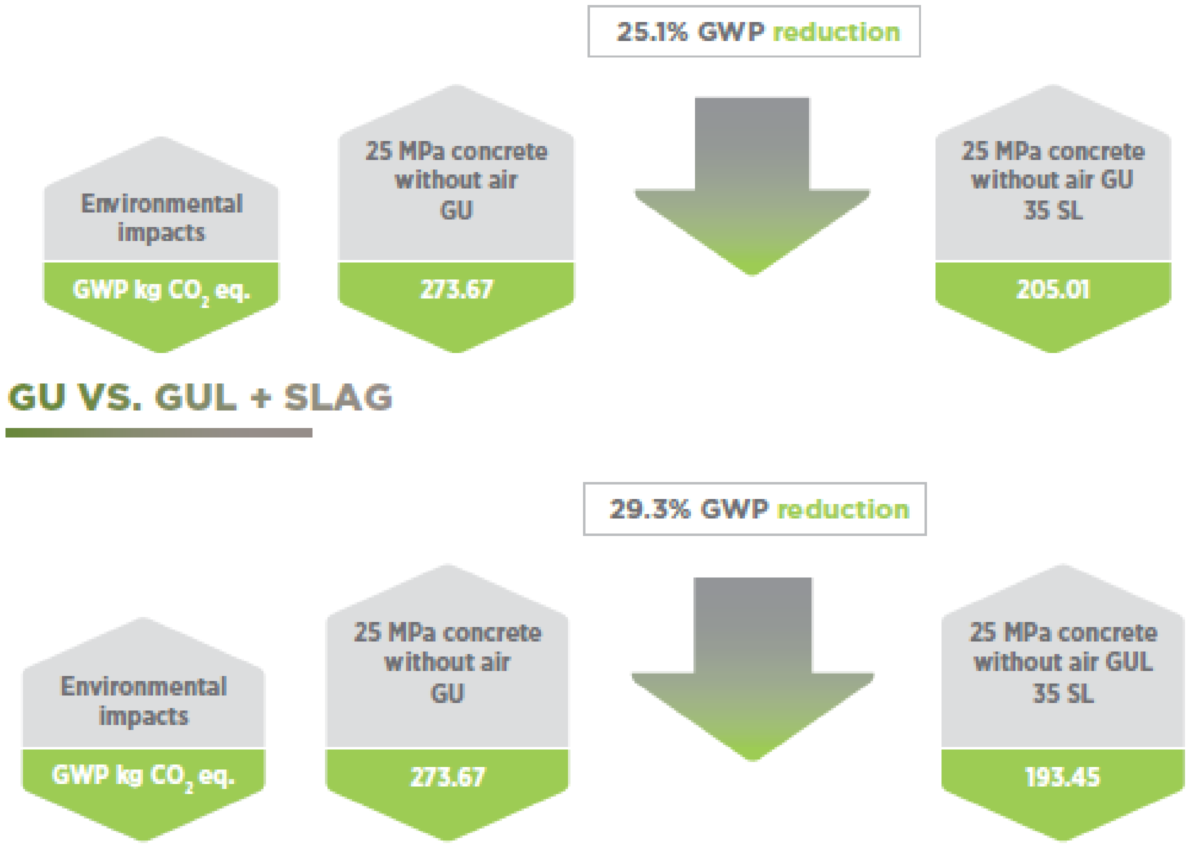
Producing Low Carbon Concrete

Maximize the Use of Supplementary Cementitious Materials (SCMs)

- Cement Type & SCM usage can result in dramatic reductions



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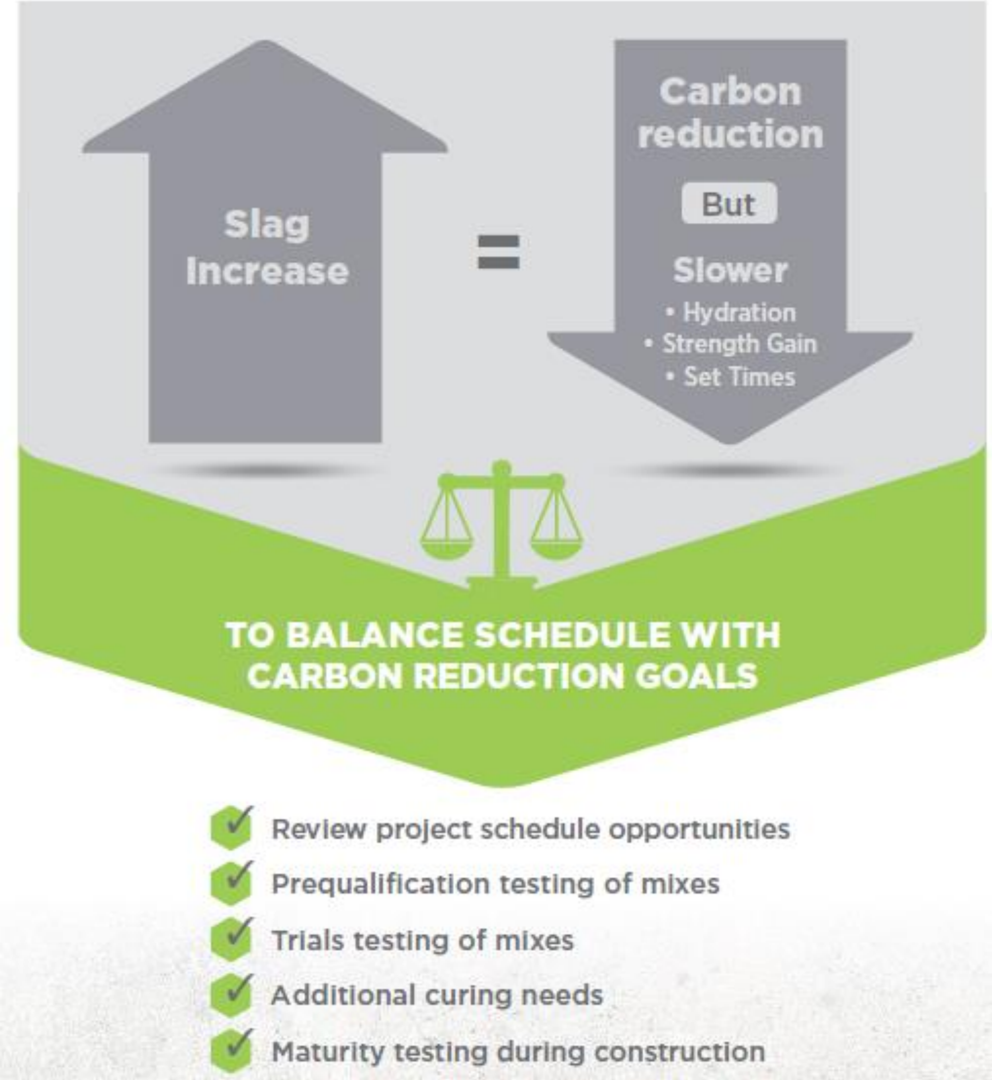
Producing Low Carbon Concrete

Maximize the Use of Supplementary Cementitious Materials (SCMs)



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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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Utilize Chemical Admixtures

- Water reduction
- Improved placeability
- Innovative carbon sequestration systems

Producing Low Carbon Concrete

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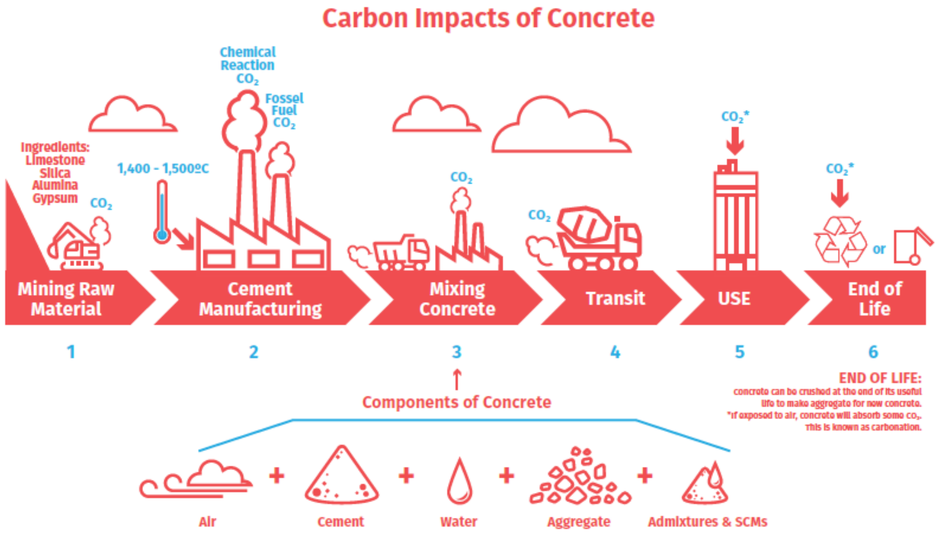
- **Industry Average** – CRMCA Ontario Report
- **Type II** – Facility Specific
- **Type III** – Facility Specific & Third Party Verified

What are the Differences Between EPD Types?



NRMCA® CERTIFIED EPD

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So How Do We Use the Ontario Industry Average EPD Report?

- Identifying **Baseline GWP values**
- Reviewing the Tables for **Cement Type** and **SCM Replacement Impacts**

Table 22. LCA Results 40 MPa concrete with air

	Unit	Baseline 40 MPa concrete with air GU 15 SL	40 MPa concrete with air GU	40 MPa concrete with air GU 15 SL	40 MPa concrete with air GU 25 SL	40 MPa concrete with air GU 35 SL	40 MPa concrete with air GU 50 SL	40 MPa concrete with air GUL	40 MPa concrete with air GUL 15 SL	40 MPa concrete with air GUL 25 SL	40 MPa concrete with air GUL 35 SL	40 MPa concrete with air GUL 50 SL
Environmental impacts												
GWP	kg CO_2 eq.	361.65	407.45	361.65	331.12	300.59	254.79	379.78	338.13	310.36	282.60	240.95
ODP	kg CFC-11 eq.	9.62E-06	9.40E-06	9.62E-06	9.76E-06	9.91E-06	1.01E-05	8.97E-06	9.25E-06	9.44E-06	9.63E-06	9.92E-06
EP	kg N eq.	0.29	0.31	0.29	0.27	0.26	0.24	0.29	0.27	0.26	0.25	0.23
AP	kg SO_2 eq.	1.67	1.74	1.67	1.63	1.58	1.51	1.65	1.59	1.55	1.52	1.46
POCP	kg O_3 eq.	27.62	27.98	27.62	27.38	27.15	26.79	26.71	26.54	26.43	26.32	26.15

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How Do We Address Carbon Accounting for Early Strength Development?

- **Government Services Administration**
  - High Early Strength = 1.35
- **Treasury Board of Canada Secretariat**
  - **Not currently finalized**
  - High Early Strength = 1.30

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GSA

Canada

How Do We Address Carbon Accounting for Cold Weather Construction?

- **Government Services Administration**
  - Not addressed (low % of construction)
- **Treasury Board of Canada Secretariat**
  - **Not currently finalized**
  - Cold Weather Construction = 1.30

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How Do We Address Carbon Accounting for Specialty and High-Performance Concrete?

- **Government Services Administration**
  - Lightweight Concrete = 1.40
- **Treasury Board of Canada Secretariat**
  - **Not currently finalized**
  - Specialty/High Performance = 1.30

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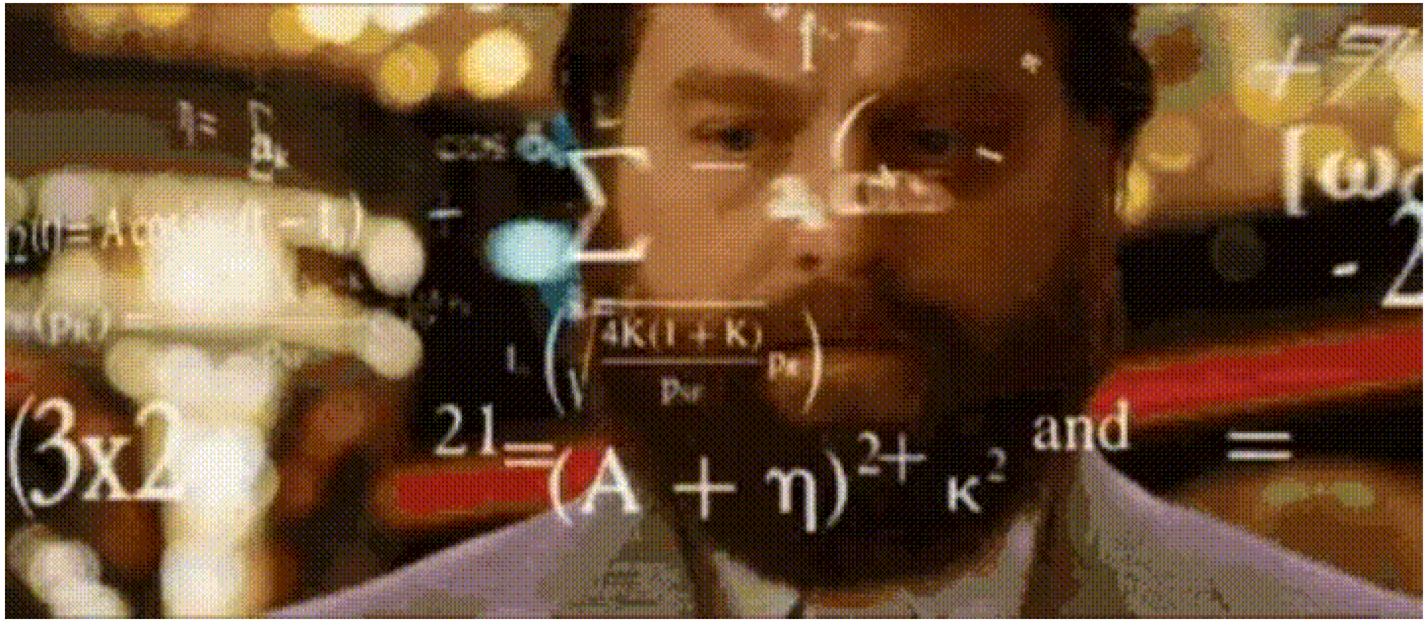
How Do We Use This Information To Reduce The Concrete Carbon Impact On A Real Project?



The Met

2016-2019
Vaughan, ON

Condo Case Study

The Met – Vaughan, ON

Image credit: Plaza/Berkley

The Met
Overview

- 35-storey condominium tower with 3 levels of underground parking
- ~30,000 m^3 of concrete
  - ~15,000 m^3 accelerated concrete
- Carbon reduction goals were not considered
- Low carbon concrete solutions were not the primary focus
- The case study's primary purpose is to showcase how a typical project schedule and special application mix designs, such as cold weather concreting can impact concrete carbon budgets

The Met

Concrete needs

- 20 mix designs were submitted by the ready mixed producer to the contractor

- 140 different mix design variations were used upon project completion

- Mix design variations included a variety of performance enhancements such as:

1. Accelerated set and strengths
2. Enhancement of slumps
3. Aggregate size adjustments
4. Fiber usage
5. Specialty admixtures (e.g., Corrosion
6. inhibitors and retarders)

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The Met
Concrete needs

Mix Design	Applications
15 MPa without air	N/A
25 MPa without air	Interior slabs
25 MPa Class C-4	Slab on grade
30 MPa without air	Footings, slabs, columns & walls (21st floor – roof)
30 MPa Class F-1	Balconies, terraces, mechanical PH roof
35 MPa without air	Slabs & beams, columns & walls (14th floor – u/s 21st floor)
35 MPa Class F-2	Perimeter foundation walls, columns & walls (14th floor – u/s 21st floor)
35 MPa Class C-1	Parking slabs, balconies & terraces
40 MPa without air	Columns & walls (7th floor – u/s 14th floor)
45 MPa without air	Beams, pick-up slabs, columns & walls (2nd floor – u/s 7th floor)
45 MPa Class F-2	Columns & walls (2nd floor – u/s 7th floor)
45 MPa Class C-1	N/A
50 MPa without air	Columns & walls
50 MPa Class F-2	Columns & walls
60 MPa Class F-2	N/A

- The cement type for all concrete was either **Type GU or Type GUbSF** since Type GUL was not yet readily available

The Met
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

$$\boldsymbol{GHG\ reduction = CO2e\ Baseline - CO2e\ Project}$$

CO2e Baseline 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)

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

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Carbon Reduction Goals

- Each owner and specifier can make the determination what carbon reduction goals they would like to achieve

- Communication between entire construction team is critical

- The total project GHG emissions from ready mixed concrete shall be at least 10% less than those calculated using the GWPs of the equivalent Ontario Industry-Average Baseline EPDs for each mix strength class and volume of mix placed. **(i.e., % GHG Reduction Calculation of 10%)**

- As more and more projects are completed using concrete carbon budgeting the achievable GHG reduction goals will emerge

Step 1:
Calculate Anticipated CO_2e Baseline

Image credit: someMidTowner, UrbanToronto

Mix Design	Anticipated Volume (m^3)	Application	Ontario Industry-Average EPD Baseline Mix	Baseline GWP (kg CO_2/m^3)	CO2e Baseline (tonnes CO_2)
15 MPa without air	600	Standard	**Baseline 20 MPa concrete without air GU 10 SL	220.29	132.2
25 MPa without air	7,000	Standard	Baseline 25 MPa concrete without air GU 10 SL	254.05	1,778.4
25 MPa Class C-4	900	Standard	**Baseline 25 MPa concrete with air & 0.55 w/cm (F-2) GU 10 SL	260.64	234.6
30 MPa without air	2,500	Standard	Baseline 30 MPa concrete without air GU 15 SL	264.38	660.9
30 MPa Class F-1	3,500	Standard	Baseline 30 MPa concrete with air & 0.50 w/cm (F-1) GU 15 SL	292.72	1,024.5
35 MPa without air	2,500	Standard	Baseline 35 MPa concrete without air GU 15 SL	295.46	738.7
35 MPa Class F-2	1,500	Standard	Baseline 35 MPa concrete with air GU 15 SL	334.49	501.7
35 MPa Class C-1	5,250	Standard	Baseline 35 MPa concrete with air & 0.40 w/cm (C-1) GU 25 SL	313.07	1,643.6
40 MPa without air	1,000	Standard	Baseline 40 MPa concrete without air GU 15 SL	326.25	326.3
45 MPa without air	3,000	Standard	Baseline 45 MPa concrete without air GU 15 SL	349.88	1,049.7
45 MPa Class F-2	20	Standard	Baseline 45 MPa concrete with air GU 15 SL	379.45	7.6
45 MPa Class C-1	1,700	Standard	**45 MPa concrete with air GU 25 SL	347.24	590.3
50 MPa without air	70	Standard	Baseline 50 MPa concrete without air GUbSF 20 SL	335.76	23.5
50 MPa Class F-2	1,100	Standard	Baseline 50 MPa concrete with air GUbSF 20 SL	456.93	502.6
60 MPa Class F-2	150	Standard	**50 MPa concrete with air GUbSF	535.65	80.3
Total:	**30,790**			**Total:**	**9,294.9**

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- Baselines are used as a starting point for carbon budgeting, not acceptance/rejection criteria.

Step 2:
Adjust & Calculate Final CO2e Baseline

Image credit: DarkSideDenizen, UrbanToronto

Mix Design	Application	Total Volume (m^3)	Ontario Industry-Average EPD Baseline Mix	Baseline GWP (kg CO_2/m^3)	Updated Baseline GWP (kg CO_2/m^3) (30% increase)	CO2e Baseline (tonnes CO_2)
15 MPa without air	Standard	626.0	Baseline 20 MPa concrete without air GU 10 SL	220.29	N/A	137.9
25 MPa without air	Standard	2,596.2	Baseline 25 MPa concrete without air GU 10 SL	254.05	N/A	659.6
25 MPa Class C-4	Standard	548.0	Baseline 25 MPa concrete with air & 0.55 w/cm (F-2) GU 10 SL	260.64	N/A	142.8
30 MPa without air	Standard	943.0	Baseline 30 MPa concrete without air GU 15 SL	264.38	N/A	249.3
30 MPa Class F-1	Standard	1,090.6	Baseline 30 MPa concrete with air & 0.50 w/cm (F-1) GU 15 SL	292.72	N/A	319.2
35 MPa without air	Standard	2,031.0	Baseline 35 MPa concrete without air GU 15 SL	295.46	N/A	600.1
35 MPa Class F-2	Standard	1,184.8	Baseline 35 MPa concrete with air GU 15 SL	334.49	N/A	396.3
35 MPa Class C-1	Standard	2,245.8	Baseline 35 MPa concrete with air & 0.40 w/cm (C-1) GU 25 SL	313.07	N/A	703.1
40 MPa without air	Standard	1,123.0	Baseline 40 MPa concrete without air GU 15 SL	326.25	N/A	366.4
45 MPa without air	Standard	1,827.4	Baseline 45 MPa concrete without air GU 15 SL	349.88	N/A	639.4
45 MPa Class F-2	Standard	9.0	Baseline 45 MPa concrete with air GU 15 SL	379.45	N/A	3.4
45 MPa Class C-1	Standard	909.6	45 MPa concrete with air GU 25 SL	347.24	N/A	315.9
50 MPa without air	Standard	68.6	Baseline 50 MPa concrete without air GUbSF 20 SL	335.76	N/A	23.0
50 MPa Class F-2	Standard	411.0	Baseline 50 MPa concrete with air GUbSF 20 SL	456.93	N/A	187.8
60 MPa Class F-2	Standard	132.0	50 MPa concrete with air GUbSF	535.65	N/A	70.7

Step 2B:

Adjust & Calculate Anticipated CO2e Baseline For Any Special Application Mixes

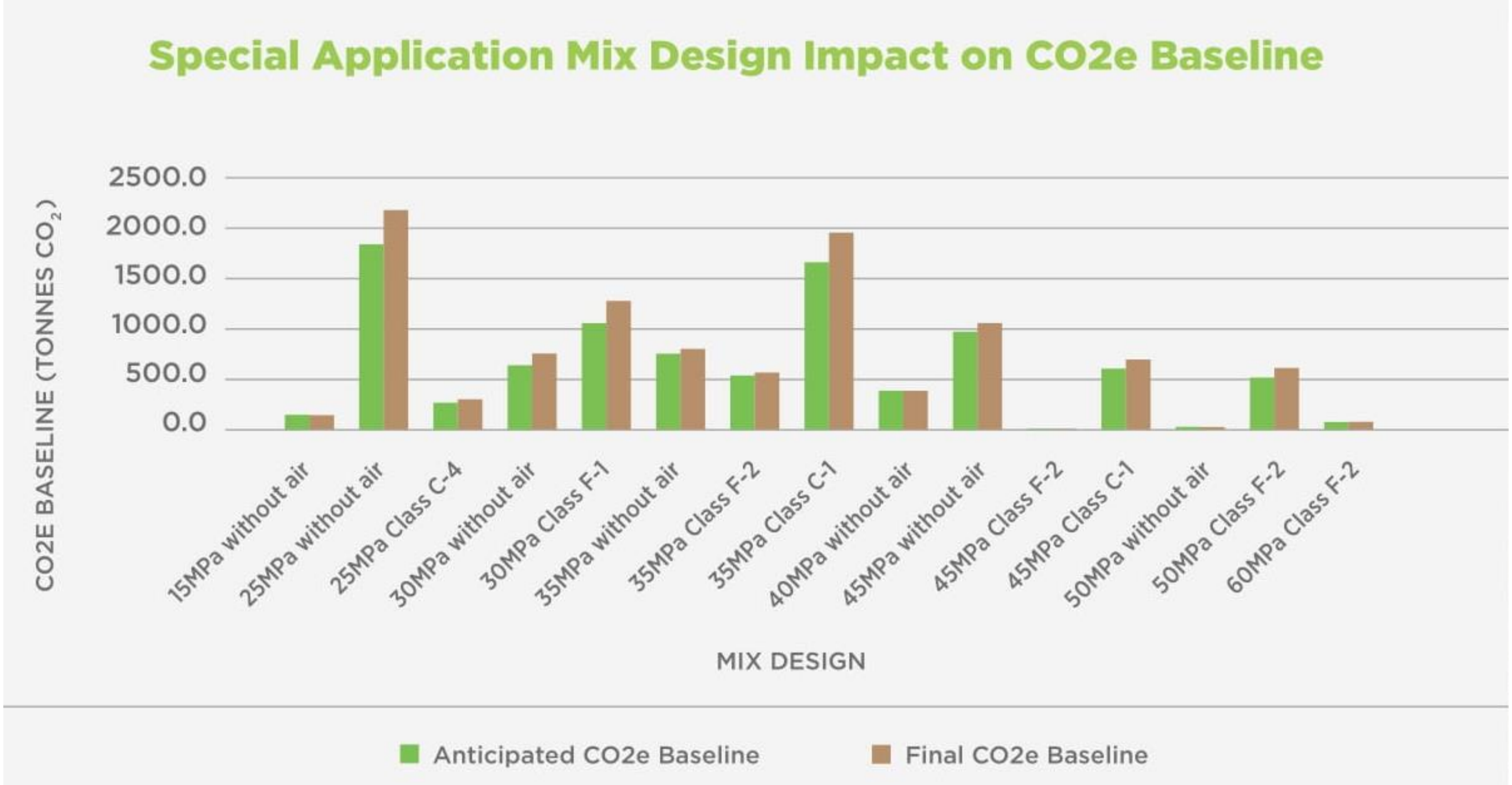
Image credit: DarkSideDenizen, UrbanToronto

Mix Design	Application	Total Volume (m^3)	Ontario Industry-Average EPD Baseline Mix	Baseline GWP (kg CO_2/m^3)	Updated Baseline GWP (kg CO_2/m^3) (30% increase)	CO2e Baseline (tonnes CO_2)
25 MPa without air	Special	408.4	Baseline 25 MPa concrete without air GU 10 SL	254.05	330.27	134.9
25 MPa Class C-4	Special	457.4	Baseline 25 MPa concrete with air & 0.55 w/cm (F-2) GU 10 SL	260.64	338.83	155.0
30 MPa without air	Special	1,421.6	Baseline 30 MPa concrete without air GU 15 SL	264.38	343.69	488.6
30 MPa Class F-1	Special	809.8	Baseline 30 MPa concrete with air & 0.50 w/cm (F-1) GU 15 SL	292.72	380.53	308.2
35 MPa without air	Special	147.6	Baseline 35 MPa concrete without air GU 15 SL	295.46	384.10	56.7
35 MPa Class F-2	Special	362.0	Baseline 35 MPa concrete with air GU 15 SL	334.49	434.84	157.4

- High early strength
- Specialty and high-performance
- Cold-weather application

The baseline (AveGWP in the example) used for Special Application Requirements shall be 130% of the Ontario Industry-Average Baseline EPDs for that strength class.

Mix Design	Application	Total Volume (m³)	Ontario Industry-Average EPD Baseline Mix	Baseline GWP (kg CO_2/m³)	Updated Baseline GWP (kg CO_2/m³) (30% increase)	CO2e Baseline (tonnes CO_2)
35 MPa Class C-1	Special	2,018.6	Baseline 35 MPa concrete with air & 0.40 w/cm (C-1) GU 25 SL	313.07	406.99	821.6
45 MPa without air	Special	592.6	Baseline 45 MPa concrete without air GU 15 SL	349.88	454.85	269.5
45 MPa Class C-1	Special	736.0	45 MPa concrete with air GU 25 SL	347.24	451.42	332.2
50 MPa Class F-2	Special	690.0	Baseline 50 MPa concrete with air GUbSF 20 SL	456.93	594.01	409.9
25 MPa without air (75% @ 24H)	Special	36.0	Baseline 25 MPa concrete without air GU 10 SL	254.05	330.27	11.9
25 MPa without air (75% @ 48H)	Special	4,064.8	Baseline 25 MPa concrete without air GU 10 SL	254.05	330.27	1,342.5
30 MPa without air (75% @ 48H)	Special	13.0	Baseline 30 MPa concrete without air GU 15 SL	264.38	343.69	4.5
30 MPa Class F-1 (75% @ 24H)	Special	69.6	Baseline 30 MPa concrete with air & 0.50 w/cm (F-1) GU 15 SL	292.72	380.53	26.5
30 MPa Class F-1 (75% @ 48H)	Special	1,585.4	Baseline 30 MPa concrete with air & 0.50 w/cm (F-1) GU 15 SL	292.72	380.53	603.3
35 MPa without air (75% @ 48H)	Special	333.0	Baseline 35 MPa concrete without air GU 15 SL	295.46	384.10	127.9
35 MPa Class C-1 (75% @ 48H)	Special	1,048.2	Baseline 35 MPa concrete with air & 0.40 w/cm (C-1) GU 25 SL	313.07	406.99	426.6
45 MPa without air (75% @ 48H)	Special	302.2	Baseline 45 MPa concrete without air GU 15 SL	349.88	454.85	137.5
45 MPa Class C-1 (75% @ 48H)	Special	72.0	45 MPa concrete with air GU 25 SL	347.24	451.42	32.5
	Total:	**30,914.2**			**Total:**	**10,661.9**



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Anticipated CO2 Baseline: 9,294.9 tonnes CO_2
Final CO2e Baseline: 10,661.9 tonnes CO_2

Step 3:
CO2e Project Calculation

Image credit: Nicholas Del Prete, UrbanToronto

Mix Design	Application	Total Volume (m^3)	Ontario Industry-Average EPD Mix	Ontario Industry-Average EPD GWP (kg CO_2)	CO2e Project (tonnes CO_2)
15 MPa without air	Standard	626.0	20 MPa concrete without air GU 15 SL	211.99	132.7
25 MPa without air	Standard	2,596.2	25 MPa concrete without air GU 15 SL	244.24	634.1
25 MPa Class C-4	Standard	548.0	25 MPa concrete with air & 0.55 w/cm (F-2) GU 25 SL	230.26	126.2
30 MPa without air	Standard	943.0	30 MPa concrete without air GU 15 SL	264.38	249.3
30 MPa Class F-1	Standard	1,090.6	30 MPa concrete with air & 0.50 w/cm (F-1) GU 15 SL	292.72	319.2
35 MPa without air	Standard	2,031.0	35 MPa concrete without air GU 30 SL	258.92	525.9
35 MPa Class F-2	Standard	1,184.8	35 MPa concrete with air GU 25 SL	306.42	363.0
35 MPa Class C-1	Standard	2,245.8	35 MPa concrete with air & 0.40 w/cm (C-1) GU 35 SL	284.38	638.7
40 MPa without air	Standard	1,123.0	40 MPa concrete without air GU 30 SL	285.48	320.6
45 MPa without air	Standard	1,827.4	45 MPa concrete without air GU 30 SL	305.72	558.7
45 MPa Class F-2	Standard	9.0	45 MPa concrete with air GU 25 SL	347.24	3.1
45 MPa Class C-1	Standard	909.6	45 MPa concrete with air GU 25 SL	347.24	315.9
50 MPa without air	Standard	68.6	50 MPa concrete without air GUbSF 25 SL	321.41	22.0
50 MPa Class F-2	Standard	411.0	50 MPa concrete with air GUbSF 25 SL	437.25	179.7
60 MPa Class F-2	Standard	132.0	50 MPa concrete with air GUbSF 25 SL	437.25	57.7
25 MPa without air	Special	408.4	Baseline 25 MPa concrete without air GU 10 SL	254.05	103.8
25 MPa Class C-4	Special	457.4	Baseline 25 MPa concrete with air & 0.55 w/cm (F-2) GU 10 SL	260.64	119.2
30 MPa without air	Special	1,421.6	Baseline 30MPa concrete without air GU 15 SL	264.38	375.8
30 MPa Class F-1	Special	809.8	30 MPa concrete with air & 0.50 w/cm (F-1) GU 15 SL	292.72	237.0
35 MPa without air	Special	147.6	35 MPa concrete without air GU 15 SL	295.46	43.6
35 MPa Class F-2	Special	362.0	Baseline 35 MPa concrete with air GU 15 SL	334.49	121.1
35 MPa Class C-1	Special	2,018.6	35 MPa concrete with air & 0.40 w/cm (C-1) GU 25 SL	313.07	632.0
45 MPa without air	Special	592.6	Baseline 45 MPa concrete with air GU 15 SL	379.45	224.9
45 MPa Class C-1	Special	736.0	45 MPa concrete with air GU 25 SL	347.24	255.6
50 MPa Class F-2	Special	690.0	50 MPa concrete with air GUbSF 15 SL	476.61	328.9

25 MPa without air (75% @ 24H)	Special	36.0	40 MPa concrete without air GU 15 SL	326.25	11.7
25 MPa without air (75% @ 48H)	Special	4,064.8	35 MPa concrete without air GU 15 SL	295.46	1,201.0
30 MPa without air (75% @ 48H)	Special	13.0	45 MPa concrete without air GU 15 SL	349.88	4.5
30 MPa Class F-1 (75% @ 24H)	Special	69.6	45 MPa concrete with air GU 15 SL	379.45	26.4
30 MPa Class F-1 (75% @ 48H)	Special	1,585.4	40 MPa concrete with air GU 15 SL	361.65	573.4
35 MPa without air (75% @ 48H)	Special	333.0	60 MPa concrete without air GUbSF 15 SL	376.81	125.5
35 MPa Class C-1 (75% @ 48H)	Special	1,048.2	50 MPa concrete with air GUbSF 25 SL	437.25	458.3
45 MPa without air (75% @ 48H)	Special	302.2	70 MPa concrete without air GUbSF 15 SL	386.50	116.8
45 MPa Class C-1 (75% @ 48H)	Special	72.0	50 MPa concrete with air GUbSF 15 SL	476.61	34.3
	Total:	**30,914.2**		**Total:**	**9,440.6**

Mix designs shown are based on the Ontario Industry-average EPD report. Access to proprietary information was required to determine which mix design most closely reflected the concrete placed.

Simplified process and improved accuracy through:

Type II EPD – Facility Specific
Type III EPD – Facility Specific & Third Party Verified

Step 4 & 5:
Calculate Green House Gas (GHG) Reduction

Image credit: someMidTowner, UrbanToronto

STEP 4: CALCULATE GHG REDUCTION

Having calculated the Final CO2e Baseline (10,661.9 tonnes CO_2) and CO2e Project (9,440.6 tonnes CO_2) values, the GHG Reduction in tonnes of CO_2 for this project is

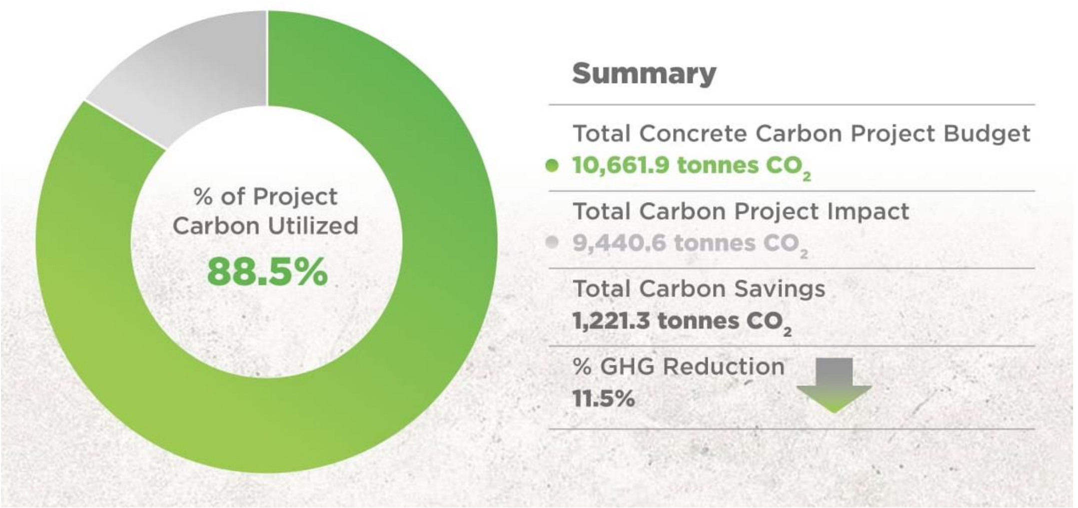
$$10{,}661.9 - 9{,}440.6 = 1{,}221.3$$

STEP 5: CALCULATE % GHG REDUCTION

Finally, using the values calculated, the % GHG Reduction for the overall project is

$$(1{,}221.3 * 100)/10{,}661.9 = 11.5\%$$

Concrete Carbon Project Summary (Type GU)



Equivalency Results

1,221.3 tonnes of CO_2 = annual emissions of the following:

339 passenger vehicles

or

471,991 litres of gasoline consumed

or

14.8 tanker trucks' worth of gasoline

or

259 homes' energy use for one year

or

741 homes' electricity use for one year

or

2,503 barrels of oil consumed

or

46,164 propane cylinders used for home barbeques

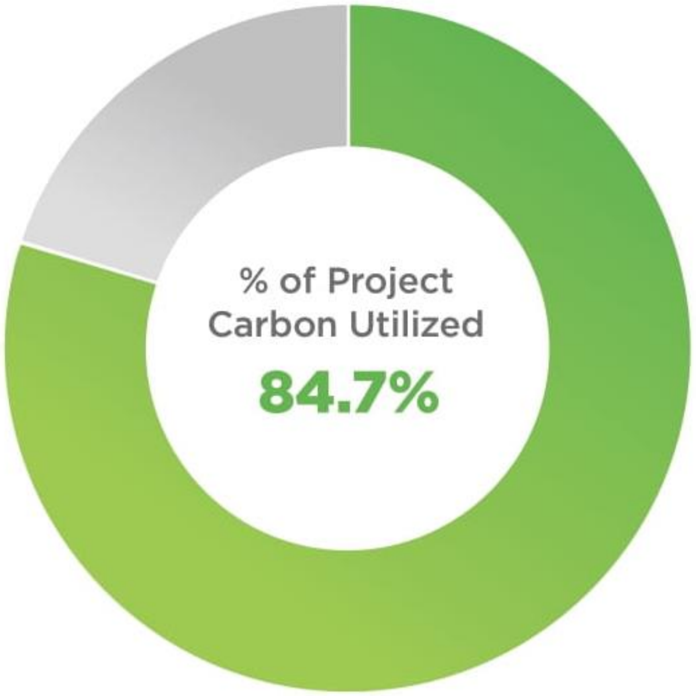
Greenhouse Gas **Equivalencies Calculator**

CONCRETE ONTARIO | Ready Mixed Concrete Association of Ontario

Source: Natural Resources Canada

https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/ghg-calculator.cfm#results

Concrete Carbon Project Summary (Type GUL)



Summary

Total Concrete Carbon Project Budget
10,661.9 tonnes CO_2

Total Carbon Project Impact
9,032.4 tonnes CO_2

Total Carbon Savings
1,629.5 tonnes CO_2

% GHG Reduction
15.3%

Equivalency Results

1,629.5 tonnes of CO_2 = annual emissions of the following:

453 passenger vehicles

or

629,747 litres of gasoline consumed

or

19.7 tanker trucks' worth of gasoline

or

346 homes' energy use for one year

or

988 homes' electricity use for one year

or

3,340 barrels of oil consumed

or

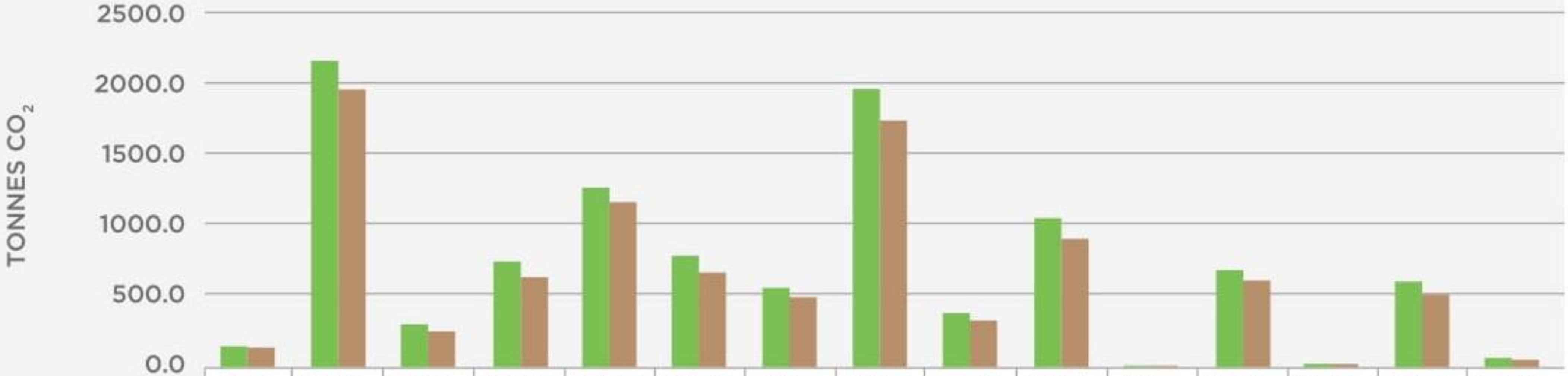
61,594 propane cylinders used for home barbeques

Greenhouse Gas **Equivalencies Calculator**

CONCRETE ONTARIO | Ready Mixed Concrete Association of Ontario

Source: Natural Resources Canada
https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/ghg-calculator.cfm#results

Final CO2e Baseline vs Project CO2e Results



	15 MPa without air	25 MPa without air	25 MPa Class C-4	30 MPa without air	30 MPa Class F-1	35 MPa without air	35 MPa Class F-2	35 MPa Class C-1	40 MPa without air	45 MPa without air	45 MPa Class F-2	45 MPa Class C-1	50 MPa without air	50 MPa Class F-2	60 MPa Class F-2
Final CO2e Baseline	137.9	2148.8	297.8	742.4	1257.2	784.7	553.7	1951.3	366.4	1046.4	3.4	680.6	23.0	597.7	70.7
CO2e Project	132.7	1950.6	245.4	629.7	1156.1	663.5	484.1	1729.0	320.6	900.3	3.1	605.7	22.0	508.6	57.7

MIX DESIGN

Final CO2e Baseline   CO2e Project

Specifier Considerations

Project Summary

Image credit: someMidTowner, UrbanToronto

30 MPa CLASS F-1 USAGE

Mix Design	Application	Total Volume (m^3)	% of Total Mix Volume	Baseline GWP (kg CO_2/m^3	Updated Baseline GWP (kg CO_2/m^3) (30% increase)	CO2e Baseline (tonnes CO_2)	Ontario Industry-Average EPD GWP (kg CO_2/m^3)	Standard Baseline versus Ontario Industry-Average EPD GWP	CO2e Project (tonnes CO_2)	Final Mix % GHG Reduction w/ Updated Baseline (30% increase)
30MPa Class F-1	Standard	1,090.6	31%	292.72	N/A	319.2	292.72	0.0%	319.24	0.0%
30MPa Class F-1	Special	809.8	23%	292.72	380.53	308.2	292.72	0.0%	237.04	23.1%
30MPa Class F-1 (75% @ 24H)	Special	69.6	2%	292.72	380.53	26.5	379.45	29.6%	26.41	0.3%
30MPa Class F-1 (75% @ 48H)	Special	1,585.4	45%	292.72	380.53	603.3	361.65	23.5%	573.36	5.0%
Total:		3,555.4								

- **Do not specify application specific GWP values for concrete carbon accounting exclusively**
- **Utilize the concept of a concrete carbon project budget and balance the schedule with mix design optimization**

Questions?

Thank you.

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