NRC·CNRC NRC-Construction

The Concrete Revolution

Building a Sustainable Future with Low Carbon Concrete

Dr. Galal Fares
Construction Research Centre

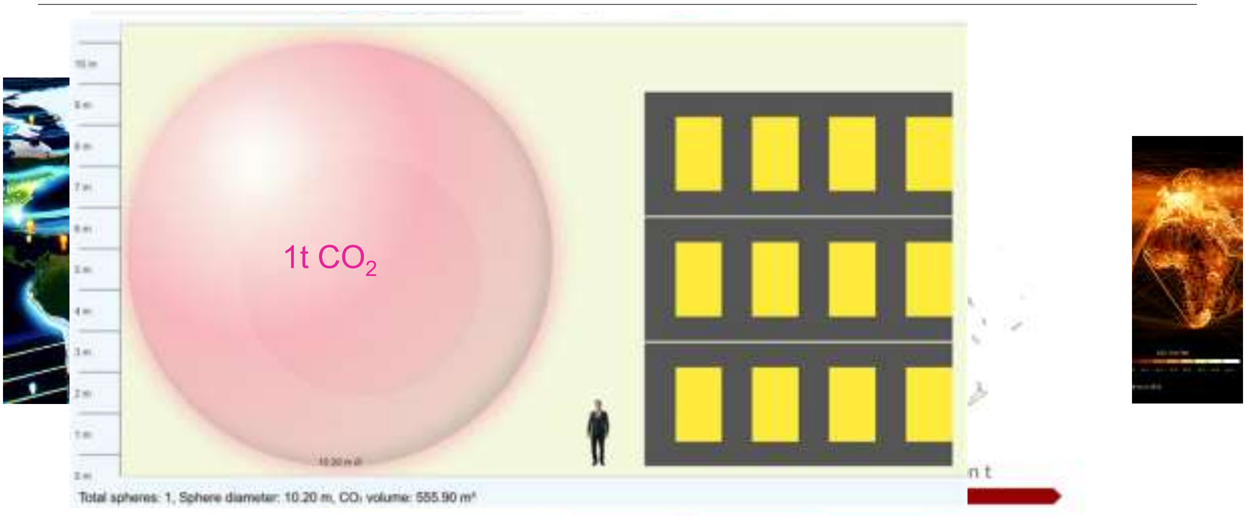
NCHCA Education Series
26 February 2026

National Research Council Canada Conseil national de recherches Canada

Canada

1

Global Cement Challenge – Beyond Numbers



By NRC Concrete team

2

2

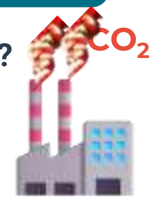
The CO_2 Challenge in Cement Production!

8% of global CO_2 emissions from cement production

4.1B tons of cement produced annually worldwide

1:1 Ratio - for every ton of cement, nearly a ton of CO_2

Why Concrete is so Carbon-Intensive?



$CaCO_3$ + Heat → CaO + CO_2↑

`1.0t cement = 1.65t limestone + 0.4t clay`

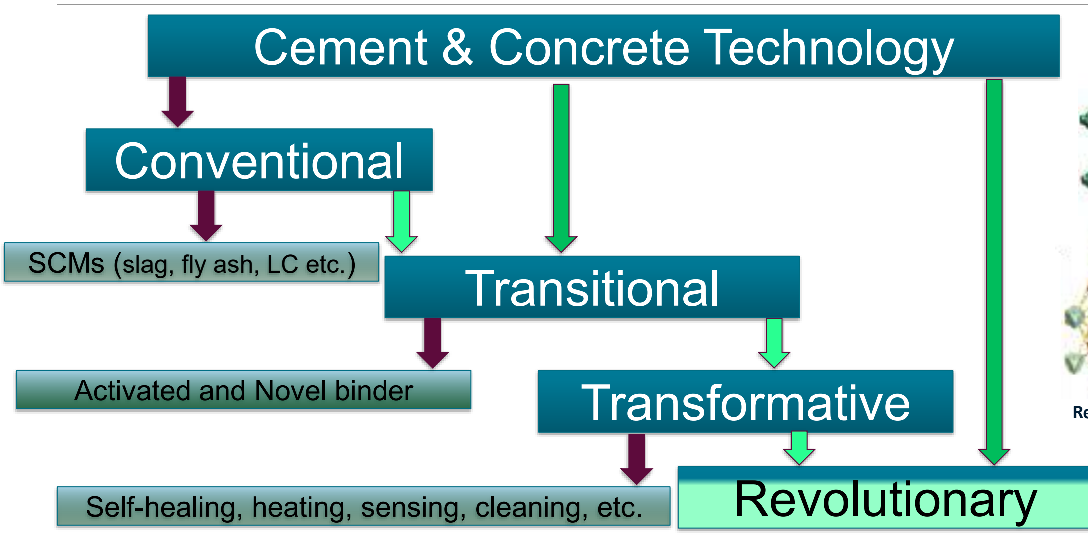
Chemical Process: Converting limestone ($CaCO_3$) to lime (CaO) releases CO_2 **(57%)**

High Heat Required: Kilns must reach 1450°C (2642°F)**(43%)**

3

3

The Chemistry of Change!



4

4

Next-Generation Concrete!

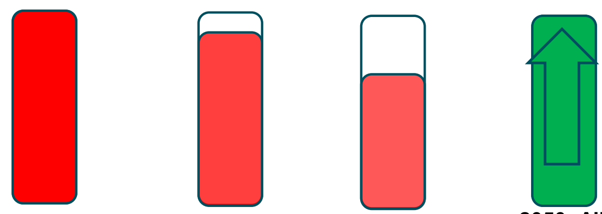
Understanding the problem to find the solution

Landfill Mining
Extracting and purifying harvested and recycled materials from existing landfill sites, creating a circular economy from past industrial waste.
> 40M tons available

Advanced Processing
Nano-treatment and activation processes that enhance harvested ash performance beyond virgin materials.
15% stronger

Carbon Negative
Each ton of harvested waste material used prevents new emissions AND cleans existing landfill sites.
-150kg CO_2/ton

- ❑ Net-negative carbon potential
- ❑ Harvested & recycled materials
- ❑ >100-year service life
- ❑ Smart, responsive properties



5

5

Canada's Roadmap to Net-Zero Carbon Concrete by 2050

- **2022** Release
- **2023** NRC National Platform
- **2023** 10% Reduction on Federal Projects
- **2030** 30% Reduction Target
- **2050** Net-Zero Carbon

Year	Key Milestone	Status
2022	Canada's Roadmap published by ISED and CAC	Already approaching parity in parts of Europe and Canada through carbon pricing and SCM adoption.
2023 – 2029	NRC National Platform to Decarbonize Construction at Scale	Ongoing research including innovative cement and concrete through platform.
2023-2030	10% GHG reduction required for concrete supplied on federal projects.	Implemented: TBS' Standard on Embodied Carbon in Construction
2030 and Beyond	Incremental reduction towards carbon neutrality	Deployment of ongoing research, innovation, and new technologies.

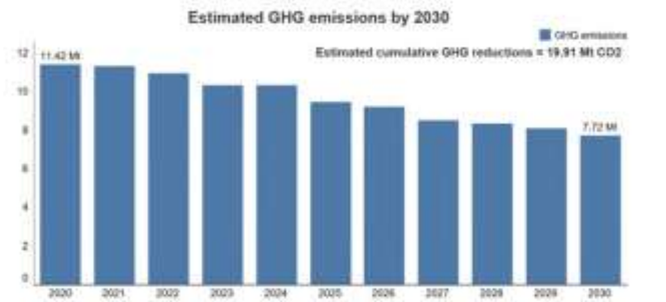
ISED = Innovation, Science and Economic Development Canada; CAC = Cement Association of Canada; TBS = Treasury Board of Canada Secretariat

6

6

Canada's Roadmap to Net-Zero Carbon Concrete by 2050

Figure 1: Estimated reductions potential against 2019 baseline[8]



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG emissions (Mt)	11.42	11.32	10.97	10.32	10.32	9.47	9.22	8.52	8.34	8.09	7.72

Estimated cumulative GHG reductions from 2019 level between 2020 and 2030 are 19.91 Mt.

CO_2 = carbon dioxide; GHG = greenhouse gas; Mt = megatonne.
* These are concrete-related emissions, including both cement emissions and other concrete-specific emissions.
** 2019 baseline emissions of 11.42 Mt of CO_2.
Source: Cement Association of Canada.

7

Breakthrough Solutions

Innovations transforming the concrete industry

Carbon Scavenger Technology
Injects and mineralizes CO_2 in fresh or recycled concrete
Permanently traps CO_2
Turning concrete into a permanent carbon sink!

Low-Carbon Binders
A modern evolution of recent and ancient Roman chemistry with modern materials (LC^3, Geopolymers, etc.)
70-80% less CO_2

Smart and Functional Concrete
Enhancing performance and sustainability.
Doubles service life

* **Bio-concrete (self-healing)**
* **Self-heating concrete**
* **Graphene- or nano-enhanced concrete**
* **Photocatalytic concrete**
* **Conductive concrete**

These are all intended to reduce the sector's carbon footprint by 50–90 %

Circular Economy and Materials recovery
Keeping materials in the loop
(**Effective Recycling**)

* **Recycled aggregate concrete (RAC)**
* **Enhanced carbonation recycling**
* **Design for deconstruction**

Digital and Process Innovations
Reducing waste and improving efficiency
(**Effective Use of Technology**)

* **3D-printed concrete (3DPC)**
* **AI-driven mix optimization & performance prediction**
* **Smart curing and monitoring**

8

NRC: Current Cement and Concrete Research Areas!

- **Clinker and Cement:**
  - Identification of new potential SCM sources (Search for New Materials)
  - SCM/ASCM Development (Aluminosilicate)
  - Alternative Cement (Limestone Calcined Clay Cement, LC^3)
  - Portland Limestone Cement
- **Concrete and Construction:**
  - Concrete Mix Optimization
  - Recycling of Cement and Concrete materials
  - Optimization of design, construction, and retrofit solutions to increase the service life of concrete structures
- **Greening Policy Levers:**
  - Guidelines: LCA, and Design for Sustainability
  - Market Understanding and Policy Support (Survey)
  - Carbon Accounting and Reporting of Materials

NRC is very interested collaboration!

9

9

Clinker and Cement:

Demonstration Study: Nemaska Project - a Canadian Success Story!

Real-world application of low-carbon concrete

Project Details

- Aluminosilicate is a by-product slag from Lithium Production
- Material Co-developed with NRC, and Nemaska Lithium
- Supports more sustainable mining and lower environmental impact.

Environmental Impact

- Similar GHG reduction to Ground-Granulated Blast Furnace Slag SCM.
- Drives economic benefit from metallurgy by-product.
- Enables more sustainable mining practices.
- Environmental impact: reduces waste and increases benefit of extraction and emissions.

10

10

Clinker and Cement:

Demonstration Study: Nemaska Project

11

11

Clinker and Cement:

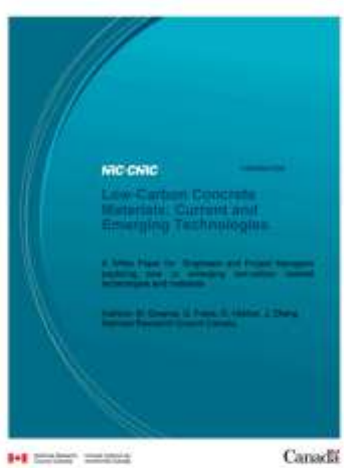
Demonstration Study: Nemaska Project

12

12

Greening Policy Levers:
Whitepaper: Deliverable and Support

A published whitepaper describing existing and emerging technologies in cement and concrete. The whitepaper looks to categorize innovations in cement and concrete and highlights the role of life cycle assessment in this process through a comprehensive overview.



13

13

Greening Policy Levers:
Low Carbon Concrete Survey

Project Details

A survey of professionals across the value chain of cement and concrete products was conducted. The idea is to understand the barriers that hinder the adoption of new construction materials.

- ❑ Asset Owners
- ❑ Architects and Engineers
- ❑ Cement and Concrete Producers
- ❑ Construction Professionals
- ❑ Standards and Associations

A huge thank you to distribution partners and respondents

- ❑ We received 251 Responses, including 135 that made it through all 50+ Questions!!!
- ❑ Publications and Follow-Up Survey are in development
- ❑ Thank you to NCHCA as a survey distributor
- ❑ And the other Public and Private organizations

14

14

Thank you

Dr. Galal Fares - galal.fares@nrc-cnrc.gc.ca
Senior Research Officer
NRC-Construction

15

16

NRC·CNRC

NRC.CANADA.CA

Life Cycle Assessment (LCA) - a tool for Sustainability Assessment

Jessica Achebe and Jieying Zhang
Centre of Excellence for Construction LCA
Construction Research Centre

NCHCA Education Series
26 February 2026

National Research Council Canada | Conseil national de recherches Canada

Canada

17

Sector

A fundamental capacity for informed design, procurement and policy decision

Drivers
Public Awareness/Climate Action
Regulatory/Compliance Driven
Trade/Industry Competitiveness

LCA Gaps
Data, Data, more Data
Integration with LCCA
Stakeholder Engagement and Implementation

LCA for Infrastructure Renewal
Sustainability
Cost-effectiveness
Resilience
Informed Decisions

18

18

Centre of Excellence for Construction LCA

Mission

- Support reducing life cycle carbon emissions by informing decisions, codes, standards, policies, and practices.
- Support the Canadian government at all levels in implementing buy-clean policies and helping the construction sector adopt and promote low-carbon solutions.

Scope

- Buildings, infrastructure, construction materials and assemblies

Research Areas

- Canadian LCA datasets, LCA methodologies, guidelines, codes and standards, and EPD and LCA tools harmonized.

Introduction

Dr. Jessica Achebe is a licensed Professional Engineer and Project Management Professional with expertise in civil engineering, sustainability, and infrastructure research. She is a Research Officer at the National Research Council of Canada (NRC), where she leads the development of national life cycle assessment (LCA) guidelines, models, and case studies for highways, bridges, and transit infrastructure, integrating environmental performance, climate resilience, and sustainability metrics into design and asset management.

Previously, she was a Postdoctoral Fellow at McMaster University, leading NSERC- and MTO-funded projects on pavement sustainability, lifecycle performance indicators, and climate adaptation strategies. She has also served as a Sustainability Consultant for the World Bank, developing GHG mitigation assessment tools and providing technical guidance for transportation projects across roads, rail, ports, airports, and urban transit.

Dr. Achebe holds a Ph.D. in Civil Engineering and Master's in Environmental Sustainability from the University of Waterloo and a Bachelor of Engineering from Igbinedion University, Nigeria. She is an active member of professional civil engineering and transportation associations and is passionate about advancing evidence-based, environmentally responsible engineering practices.

Agenda

1. Introduction – Why and what is LCA
2. LCA Framework – How we do LCA
3. Case Study Example

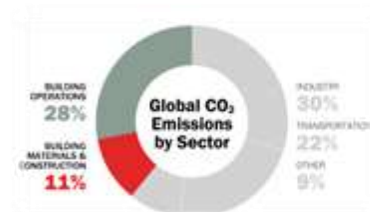
1. INTRODUCTION

Why do we need LCA?

What is LCA?

Why do we need LCA

- **Understand the full environmental impact of a product or service over its entire life cycle.**
- **Knowledge for making sustainable design decisions and minimizing environmental harm.**
- **Benefits**
  - Reduce Environmental Impact
  - Support Low-Carbon Design and Sustainable Innovation
  - Optimize Resource Use
  - Policy & Regulatory Compliance
  - Cost-Effectiveness
  - Public Awareness & Stakeholder Engagement
  - Global Sustainability Goals



CO_2 emissions related to the construction activities account for ~40% of global emissions

23

23

What is Life Cycle Assessment?

LCA is a method of measuring potential environmental impact of a process, product, project, etc.

Helps practitioners make environmentally focused design choices

LCA support sustainability while supporting decision-making

24

24

What is Life Cycle Assessment? (cont.)

Requires a great deal of user input and discretion

- Iterative process

Globally standardized by ISO 14040 & 14044

Commonly used globally, particularly in the North America & Europe

NRC – Whole Building LCA Guideline and Practitioner's Guide

NRC – Pavement and Bridge LCA Guidelines on the way

25

25

2. LCA FRAMEWORK

The 4 key stages of LCA

Basic concepts and key terms

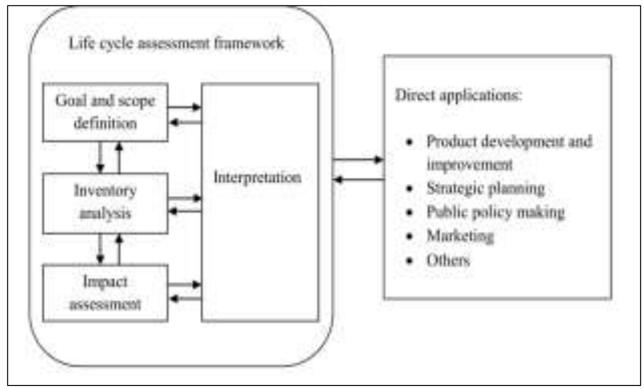
26

26

LCA Stages

According to ISO 14040 & 14044 there are four stages to LCA:

1. *Goal & Scope Definition*
2. *Life Cycle Inventory (LCI)Analysis*
3. *Life Cycle Impact Assessment (LCIA)*
4. *Interpretation*

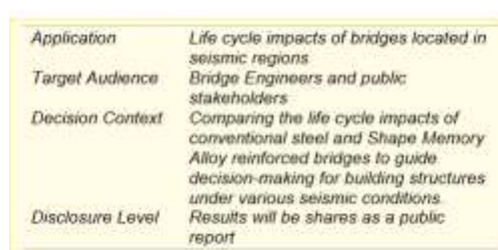


LCA Methodological Framework

Stage 1: Goal & Scope Definition

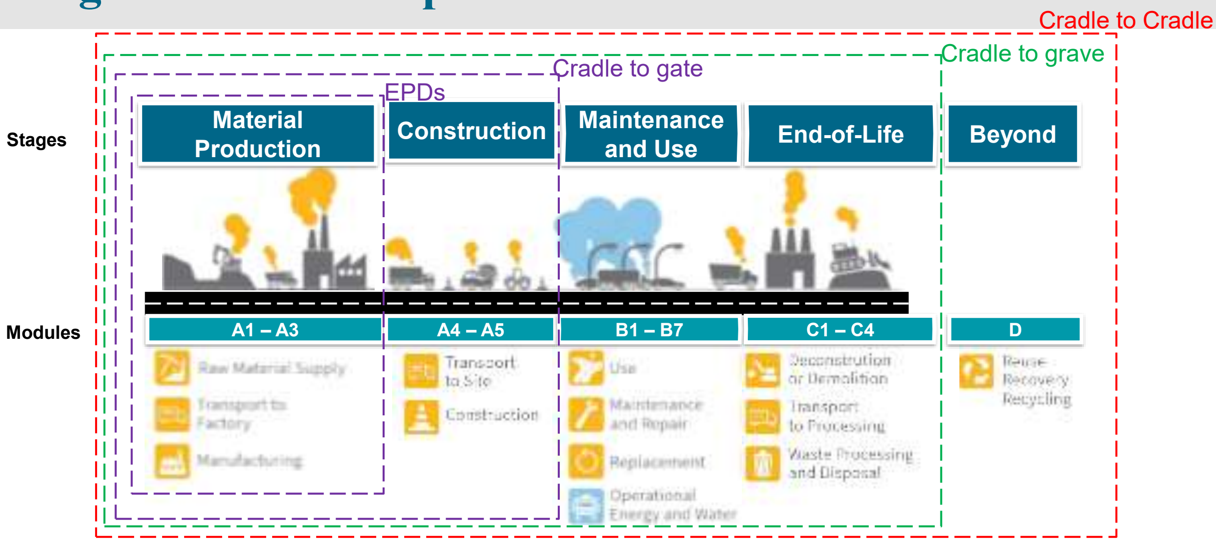
Goal key points:

- ***Application***– *What is the intended application of the LCA?*
- ***Audience*** *– Who is the study intended for?*
- ***Purpose***– *What are the reasons for conducting the LCA?*
    - *Questions to be answered*
    - *Comparative & disclosures*
    - *Attributional or Consequential*



Application	*Life cycle impacts of bridges located in seismic regions*
Target Audience	*Bridge Engineers and public stakeholders*
Decision Context	*Comparing the life cycle impacts of conventional steel and Shape Memory Alloy reinforced bridges to guide decision-making for building structures under various seismic conditions*
Disclosure Level	*Results will be shares as a public report*

Stage 1: Goal & Scope Definition



Building and Infrastructure LCA System Definition and Boundaries

29

29

Stage 1: Goal & Scope Definition

Scope key points:

- *Functional Unit*
- *Product/service system*
- *System boundaries*
- *Life cycle models*
- *Desired impact categories*
- *Data Needed*

Other factors for Goal and Scope:

- *Allocation requirement*
- *Desired impact categories*
- *Required life cycle impact assessment (LCIA) model*
- *Required data quality*

Functional Unit	*A bridge allowing pedestrians to cross the ditch for 100 years*
Assessment Method	*TRACI 2.2*
System Boundary	*Cradle-to-grave (A1-C4)*

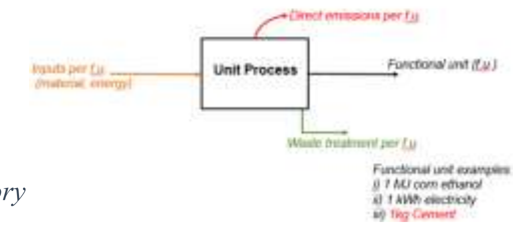
30

30

Stage 2: Inventory Analysis

LCA requires LCI data for inputs and outputs to model the process

- Data Collection
- Data Analysis
- Database



Inventory must include:

- ***General Description*** *– Brief description of the inventory*
- ***Location*** *– Regional data*
- ***Elementary Materials*** *– Quantitative data for constituent inventory*
- ***Impact Factors*** *– Environmental impact data and factors*

Inputs are found in ***LCI databases*** *such as Ecoinvent, GaBi, and many more*

31

31

Stage 2: Inventory Analysis - Data Analysis

Consider an example for Material Production inventory:

Example: 1 m³ Ready-Mix Concrete (30 MPa)

Material / Process	Quantity	Unit	Emission Factor	Unit	Emissions (kg CO_2e)
Portland Cement	350	kg	0.9	kg CO_2e/kg	315
Coarse Aggregate	1,050	kg	0.005	kg CO_2e/kg	5.25
Fine Aggregate	750	kg	0.005	kg CO_2e/kg	3.75
Fly Ash (SCM)	70	kg	0.02	kg CO_2e/kg	1.4
Batching Plant Electricity	5	kWh	0.12	kg CO_2e/kWh	0.6
Total A1–A3 Emissions					**326 kg CO_2e / m³**

Inventory Calculation (A1–A3)

A1–A3 GWP

=∑(Material Quantity × EF)
+(Electricity × EF)

32

32

Stage 2: Inventory Analysis - Data Analysis

Consider an example for construction stage inventory:

Task	Type	Productivity (units/hr)	Units	Equipment Type [number required]	Fuel Use (gal/hr)
Excavation	Earthwork	325	Cubic Yard	Roller - Soil [1]	5.40
				Dozer [1]	4.90
				Loader - R/T [1]	5.60
				Dozer [1]	4.90
				Truck - Water [1]	5.50

Total Emissions **Gram/reference unit (i.e. square yard removal, cubic yard excavation)**

=

Emission Factor for Upstream Process Fuel A **(kg/L of fuel A)** X Activity Data (**L of Fuel A/Reference Unit)** + Emission Factor for Combusting Fuel A **(kg/L of Fuel A)** X Activity Data **Gal of Fuel A/Reference Unit**

LCI analysis is Data-driven

By the end of LCI analysis, we would have the following information already, for example, in terms of carbon emissions only:

1. **The total amount of emissions**
2. **Emissions in every life cycle phase**
3. **Emissions from different activities**

ISO 14044:2006(E)

A.5 Example of life cycle inventory analysis data collection sheet

Unit process identification:			Reporting location:
Emissions to air [a]	Units	Quantity	Description of sampling procedures (attach sheets if necessary)
Emissions to water [b]	Units	Quantity	Description of sampling procedures (attach sheets if necessary)
Emissions to land [c]	Units	Quantity	Description of sampling procedures (attach sheets if necessary)
Other releases [d]	Units	Quantity	Description of sampling procedures (attach sheets if necessary)
Describe any unique calculations, data collection, sampling, or variation from description of unit process functions (attach additional sheets if necessary).			

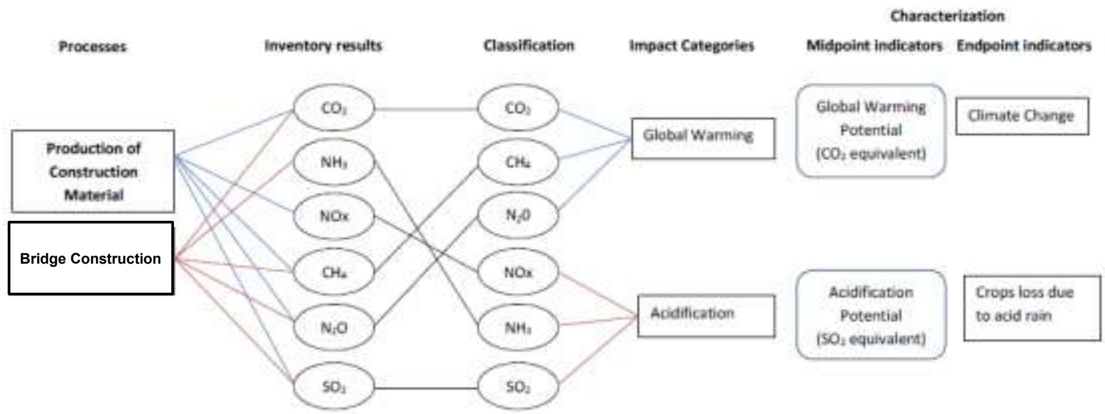
[a] For example inorganics: Cl_2, CO, CO_2, dust/particulates, F_2, H_2S, H_2SO_4, HCl, HF, N_2O, NH_3, NO_x, SO_x; and organics: hydrocarbons, PCB, dioxins, phenols; metals: Hg, Pb, Cr, Fe, Zn, Ni.

[b] For example: BOD, COD, acids, Cl_2, CN^-, detergents/oils, dissolved organics, F^-, Fe ions, Hg ions, hydrocarbons, Na^+, NH_4^+, NO_3^-, organochlorides, other metals, other nitrogen compounds, phenols, phosphates, SO_4^{2-}, suspended solids.

[c] For example: mineral waste, mixed industrial waste, municipal solid waste, toxic wastes (please list compounds included in this data category).

[d] For example: noise, radiation, vibration, odour, waste heat.

Stage 3: Impact Assessment



Classification and Characterization of Different LCIA Phases

35

35

Stage 4: Interpretation

"Final" step where results are analyzed

Recommendation can be made to reduce impact severity

Practitioners may wish to return to previous stages to alter the inventories or selected impact categories

- Helps find lower impact materials
- Use of new materials will alter which impact categories must be considered

36

36

3. ROAD REHABILITATION CASE STUDY

High Reclaimed Asphalt Pavement (RAP) Project

37

37

Case study 1- High RAP Project

The York Region had a goal of implementing an innovative pavement rehabilitation project using high proportions of RAP and WMA technology in surface and base layer mixes.

***Location*: York, ON**
5 road segments

Roadway	Segment	%RAP SL	%RAP L	Thickness (mm)
Control	Road 1 N&S	0%	10%	220
Road 2	Road 2 N	**30%**	10%	220
Road 3	Road 3 N1	0%	**40%**	190
	Road 3 N2	0%	**30%**	190
Road 4	Road 4 N	**20%**	10%	190

38

38

Stage 1

Goal: To quantify the Greenhouse Gas (GHG) impacts and environmental performance of asphalt removal, paving, and road improvements utilizing sustainable innovations (High RAP and Warm Mix Asphalt).

- Identify emission hotspots
- Evaluate RAP and binder-related sensitivities
- Support low-carbon pavement decision-making

Scope: The assessment scope is defined as Cradle-to-Gate.

Functional Units: Total As-built and 1km 2lane road segments

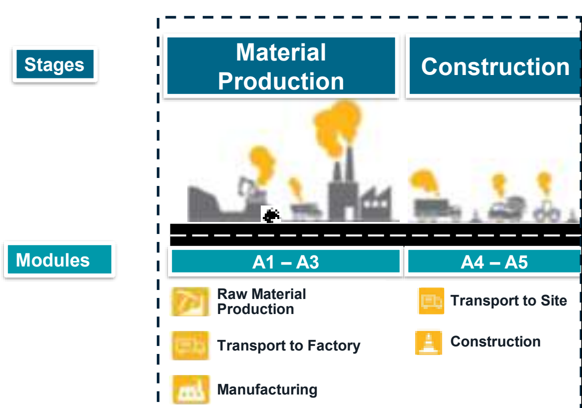
Intended Audience: York Region asset managers, qualified practitioners, pavement engineers, researchers, asset managers, and decision-makers

39

39

Stage 1 (cont.)

System Boundary



Allocation Requirements: A1 to A3 Life Cycle Modules – Substitution criteria for RAP

Desired Impact Categories: Climate Change impact – Global Warming Potential over a 100-year horizon (GWP100) in Kg CO_2 eq.

40

40

Stage 2 – LCI

Project Data Sources:

- Primary project inputs
  - Segment geometry & quantities -Total inventory of 66,635 tonnes of WMA
  - Job Mix Formulas (binder %, RAP %)
  - RAP Binder Replacement Ratios (BRR)
  - Transport distances - specific haul distances (4.6 km to 10.8 km)
  - Equipment fuel assumptions / telemetry - Mandated equipment types (Wirtgen millers, RoadTec pavers)
- Secondary data
  - Emission factors (binder, aggregate, diesel)
  - Default plant energy values (where measured data unavailable)

41

41

Stage 2 – LCI: Data Collection

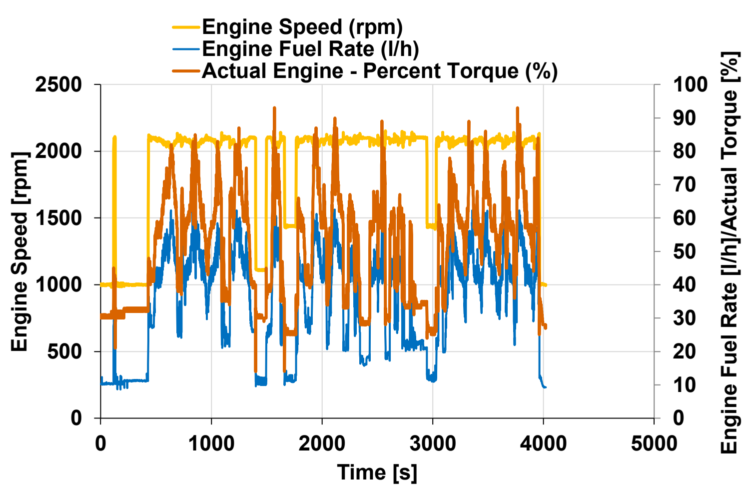
Example - Paving Equipment Data

Where A5 construction emissions: measured fuel consumption

Duty cycles: idle and high-load operation

Fuel use: ≈10–80 L/h, governed by torque rather than engine speed

Idle time: ~15–20% materially affects total emissions



42

42

Stage 2 – LCI: Data Analysis

Inventory Flow Logic

Geometry & Design Inputs
↓
Total Mix Mass
↓
Binder & Aggregate Split
↓
RAP Adjustment (BRR Applied)
↓
Virgin Binder & Aggregate Quantities
↓
LCIA: GWP Calculation (A1)

Inventory Table (Example):

Item	Unit	Example
Virgin binder	t	BRR-corrected
Virgin aggregate	t	RAP-adjusted
RAP processed	t	Screened/crushed
Diesel (transport)	L	A2 + A4
Diesel (construction)	L	A5

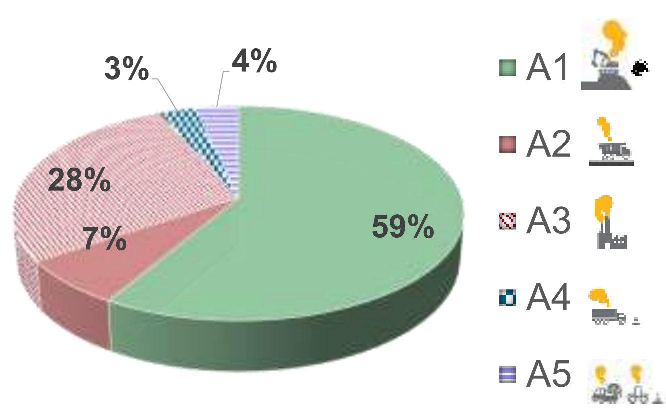
43

43

Step 3 - The LCA Result

Total project embodied carbon (A1-A5) = 4,018,638 kg CO_2e ≈ 4020 t CO_2e

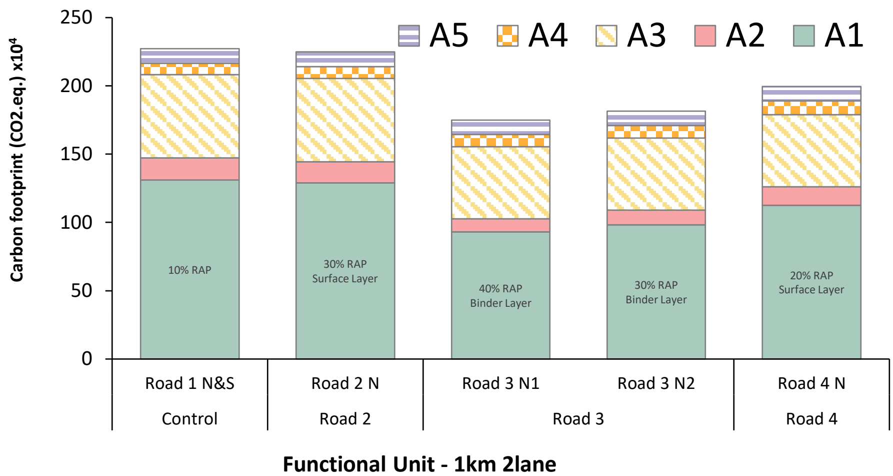
- **A1: Material Production** - Dominant Burden
- **A4: Mix Transportation** - Lowest Burden
- **A5: Construction & Waste** - Minimal Burden



44

44

Context: 1km 2lane Scale RAP Impact on Carbon

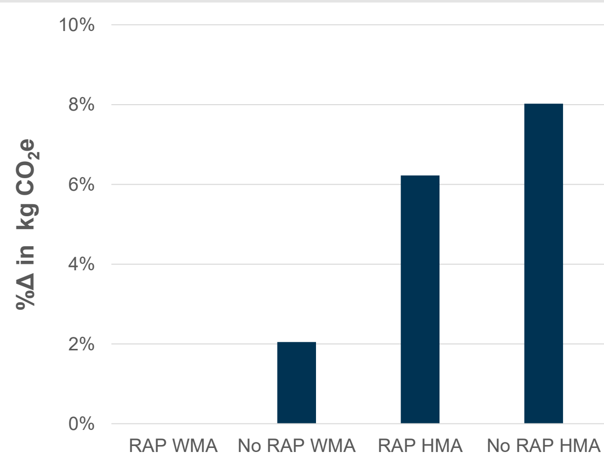


Road	% Δ kg CO_2e
Road 2 N	⬇ 1%
Road 3 N1	⬇ 30%
Road 3 N2	⬇ 25%
Road 4 N	⬇ 14%

Step 3 - The LCA Result: Mitigation Effectiveness- WMA vs. RAP

Total project embodied carbon (A1-A5) ≈ 4,020 t CO_2e

- **RAP addition** ≈ 84 t CO_2e saving compared to No RAP in project
- **WMA** ≈ 266 t CO_2e saving compared to HMA
- **RAP +WMA** ≈ 351 t CO_2e saving compared to HMA (No RAP)



Stage 4 – Interpretation and Recommendations

Materials, Design and Construction:

- Increase RAP where feasible, RAP use in binder vs surface led to higher benefit
- Consider lower-carbon binders
- Prioritize WMA where feasible, proven higher GWP reduction for project level impact (A1-A5)
- Reduce idle time
- Adopt standardized BRR reporting
- Pair construction equipment telemetry with LCA
- Prepare for LCA-based procurement

47

47

Key Takeaways

- LCA Supports Decisions -Practical applications
  - Compare RAP strategies
  - Support low-carbon specifications
  - Inform procurement and sourcing
  - Align with EPD and climate targets
- LCA follows a structured four-stage process
- Good results depend on good inventory logic
- Assumptions must be explicit
- Sensitivity analysis is essential

LCA is a decision tool, not an academic exercise.

48

48

NRC.CANADA.CA

THANK YOU

Jessica Achebe and Jieying Zhang

Jessica.achebe@nrc-cnrc.gc.ca

Jieying.zhang@nrc-cnrc.gc.ca

National Research Council Canada　Conseil national de recherches Canada

49

50

NRC·CNRC NRC-Construction

The Concrete Revolution

Building a Sustainable Future with Low Carbon Concrete

Dr. Galal Fares
Construction Research Centre

NCHCA Education Series
26 February 2026

National Research Council Canada | Conseil national de recherches Canada

Canada

51

Global Cement Challenge – Beyond Numbers

By NRC Concrete team

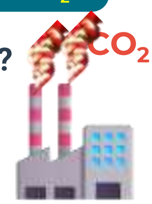
52

52

The CO_2 Challenge in Cement Production!

- **8%** of global CO_2 emissions from cement production
- **4.1B** tons of cement produced annually worldwide
- **1:1** Ratio - for every ton of cement, nearly a ton of CO_2

Why Concrete is so Carbon-Intensive?



$$CaCO_3 + Heat \rightarrow CaO + CO_2\uparrow$$

$$1.0t \text{ cement} = 1.65t \text{ limestone} + 0.4t \text{ clay}$$

Chemical Process: Converting limestone ($CaCO_3$) to lime (CaO) releases CO_2 **(57%)**

High Heat Required: Kilns must reach 1450°C (2642°F)**(43%)**

53

53

The Chemistry of Change!

Cement & Concrete Technology

- Conventional
  - SCMs (slag, fly ash, LC etc.)
- Transitional
  - Activated and Novel binder
- Transformative
  - Self-healing, heating, sensing, cleaning, etc.
- Revolutionary

Reticular chemistry

54

54

Next-Generation Concrete!

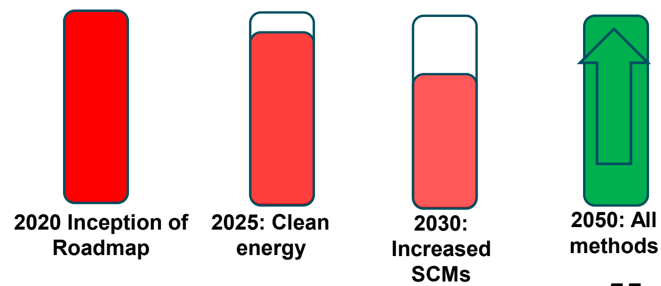
Understanding the problem to find the solution

Landfill Mining
Extracting and purifying harvested and recycled materials from existing landfill sites, creating a circular economy from past industrial waste.
> 40M tons available

Advanced Processing
Nano-treatment and activation processes that enhance harvested ash performance beyond virgin materials.
15% stronger

Carbon Negative
Each ton of harvested waste material used prevents new emissions AND cleans existing landfill sites.
-150kg CO_2/ton

- ❑ Net-negative carbon potential
- ❑ Harvested & recycled materials
- ❑ >100-year service life
- ❑ Smart, responsive properties



55

55

Canada's Roadmap to Net-Zero Carbon Concrete by 2050

2022	2023	2023	2030	2050
Release	NRC National Platform	10% Reduction on Federal Projects	30% Reduction Target	Net-Zero Carbon

Year	Key Milestone	Status
2022	Canada's Roadmap published by ISED and CAC	Already approaching parity in parts of Europe and Canada through carbon pricing and SCM adoption.
2023 – 2029	NRC National Platform to Decarbonize Construction at Scale	Ongoing research including innovative cement and concrete through platform.
2023-2030	10% GHG reduction required for concrete supplied on federal projects.	Implemented: TBS' Standard on Embodied Carbon in Construction
2030 and Beyond	Incremental reduction towards carbon neutrality	Deployment of ongoing research, innovation, and new technologies.

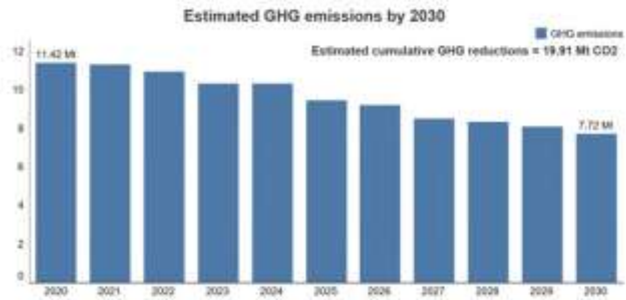
ISED = Innovation, Science and Economic Development Canada; CAC = Cement Association of Canada; TBS = Treasury Board of Canada Secretariat

56

56

Canada's Roadmap to Net-Zero Carbon Concrete by 2050

Figure 1: Estimated reductions potential against 2019 baseline*



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG emissions (Mt)	11.42	11.32	10.97	10.32	10.32	9.47	9.22	8.52	8.34	8.09	7.72

Estimated cumulative GHG reductions from 2019 level between 2020 and 2030 are 19.91 Mt.

CO_2 = carbon dioxide; GHG = greenhouse gas; Mt = megatonne.
* These are concrete-related emissions, including both cement emissions and other concrete-specific emissions.
** 2019 baseline emissions of 11.42 Mt of CO_2.
Source: Cement Association of Canada.

57

57

Breakthrough Solutions

Innovations transforming the concrete industry

Carbon Scavenger Technology
Injects and mineralizes CO_2 in fresh or recycled concrete
Permanently traps CO_2
Turning concrete into a permanent carbon sink!

Low-Carbon Binders
A modern evolution of recent and ancient Roman chemistry with modern materials (LC^3, Geopolymers, etc.)
70-80% less CO_2

Smart and Functional Concrete
Enhancing performance and sustainability.
Doubles service life

* **Bio-concrete (self-healing)**
* **Self-heating concrete**
* **Graphene- or nano-enhanced concrete**
* **Photocatalytic concrete**
* **Conductive concrete**

These are all intended to reduce the sector's carbon footprint by 50–90 %

Circular Economy and Materials recovery
Keeping materials in the loop
(**Effective Recycling**)

* **Recycled aggregate concrete (RAC)**
* **Enhanced carbonation recycling**
* **Design for deconstruction**

Digital and Process Innovations
Reducing waste and improving efficiency
(**Effective Use of Technology**)

* **3D-printed concrete (3DPC)**
* **AI-driven mix optimization & performance prediction**
* **Smart curing and monitoring**

58

58

NRC: Current Cement and Concrete Research Areas!

- **Clinker and Cement:**
  - Identification of new potential SCM sources (Search for New Materials)
  - SCM/ASCM Development (Aluminosilicate)
  - Alternative Cement (Limestone Calcined Clay Cement, LC^3)
  - Portland Limestone Cement
- **Concrete and Construction:**
  - Concrete Mix Optimization
  - Recycling of Cement and Concrete materials
  - Optimization of design, construction, and retrofit solutions to increase the service life of concrete structures
- **Greening Policy Levers:**
  - Guidelines: LCA, and Design for Sustainability
  - Market Understanding and Policy Support (Survey)
  - Carbon Accounting and Reporting of Materials

NRC is very interested collaboration!

59

59

Clinker and Cement:

Demonstration Study: Nemaska Project - a Canadian Success Story!

Real-world application of low-carbon concrete

Project Details

- Aluminosilicate is a by-product slag from Lithium Production
- Material Co-developed with NRC, and Nemaska Lithium
- Supports more sustainable mining and lower environmental impact.

Environmental Impact

- Similar GHG reduction to Ground-Granulated Blast Furnace Slag SCM.
- Drives economic benefit from metallurgy by-product.
- Enables more sustainable mining practices.
- Environmental impact: reduces waste and increases benefit of extraction and emissions.

60

60

Clinker and Cement:
Demonstration Study: Nemaska Project



61

61

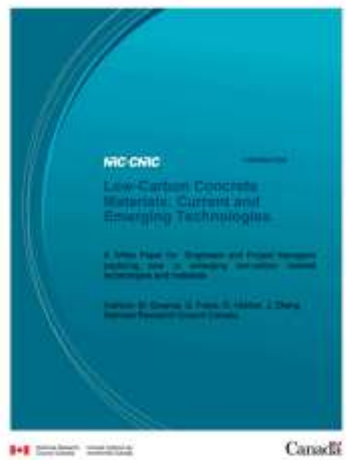
Clinker and Cement:
Demonstration Study: Nemaska Project


62

62

Greening Policy Levers:
Whitepaper: Deliverable and Support

A published whitepaper describing existing and emerging technologies in cement and concrete. The whitepaper looks to categorize innovations in cement and concrete and highlights the role of life cycle assessment in this process through a comprehensive overview.



63

63

Greening Policy Levers:
Low Carbon Concrete Survey

Project Details

A survey of professionals across the value chain of cement and concrete products was conducted. The idea is to understand the barriers that hinder the adoption of new construction materials.

- ❑ Asset Owners
- ❑ Architects and Engineers
- ❑ Cement and Concrete Producers
- ❑ Construction Professionals
- ❑ Standards and Associations

A huge thank you to distribution partners and respondents

- ❑ We received 251 Responses, including 135 that made it through all 50+ Questions!!!
- ❑ Publications and Follow-Up Survey are in development
- ❑ Thank you to NCHCA as a survey distributor
- ❑ And the other Public and Private organizations

64

64

Thank you

Dr. Galal Fares - galal.fares@nrc-cnrc.gc.ca
Senior Research Officer
NRC-Construction

65