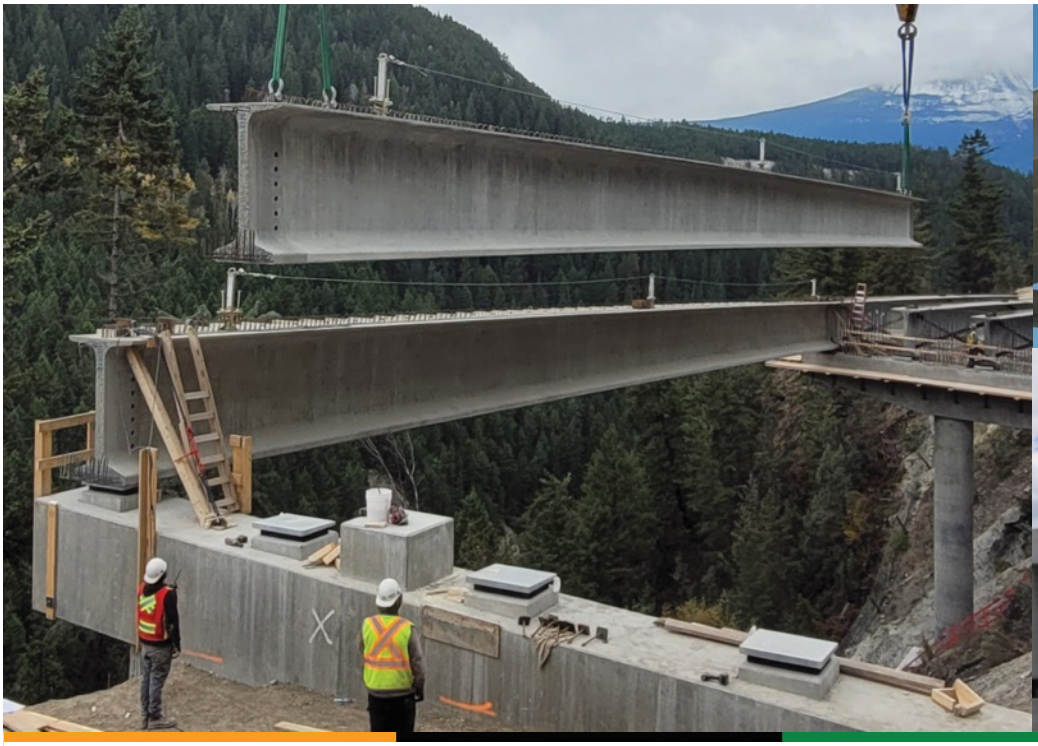

A Regionalized Industry Average EPD for Structural Precast Concrete

CANADIAN PRECAST/PRESTRESSED CONCRETE INSTITUTE

According to ISO 14025:2006 and ISO 21930:2017

ASTM INTERNATIONAL

ASTM International Certified Environmental Product Declaration

This is a Canadian regionalized industry wide (average) business-to-business Type III environmental product declaration for structural precast as produced by CPCI members. This declaration has been prepared in accordance with ISO 14025:2006 and ISO 21930:2017, the governing precast concrete category rules and ASTM international's EPD program operator rules.

The intent of this document is to further the development of environmentally compatible and more sustainable construction products by providing comprehensive environmental information related to potential impacts of structural precast available in various parts of Canada in accordance with international standards.

Environmental Product Declaration Summary

EPD Owner	
CPCI.ca CANADIAN PRECAST/PRESTRESSED CONCRETE INSTITUTE INSTITUT CANADIEN DU BÉTON PRÉFABRIQUÉ ET PRÉCONTRAINT	**Canadian Precast/Prestressed Concrete Institute** PO Box 24058 Hazeldean, Ottawa Ontario, Canada K2M 2C3 Link (URL): www.cpci.ca
Product Group and Name	Structural Precast Concrete (UN CPC 3755)
Product Definition	Structural precast concrete is a construction product produced by casting concrete in a reusable mold or "form" which is then cured in a controlled environment, transported to the construction site, and lifted into place. Structural precast concrete is used in building or civil engineering works and is primarily composed of cement, aggregates, and reinforcement materials.
Product Category Rules	NSF PCR for Precast Concrete, V3.0, May 2021. [5].
Certification Period	03.31.2023 – 03.31.2028
Declared Unit	1 metric tonne (1,000 kg) of structural precast product
ASTM Declaration Number	EPD #433

EPD Program Operator	ASTM International
Declaration Holder	Canadian Precast/Prestressed Concrete Institute
Declaration Type A regionalized industry average "cradle-to-gate" EPD for structural precast as a product group manufactured by CPCI members. Activity stages or information modules covered include production with the product ready for shipment from the point of manufacture (modules A1 to A3). The declaration is intended for use in Business-to-Business (B-to-B) communication.	
Product Applicability Structural precast concrete products satisfy a wide array of building and civil engineering applications.	
Content of the Declaration This declaration follows Section 9; Content of an EPD, NSF PCR for Precast Concrete, V3.0, May 2021 [5]	
This EPD was independently verified **by ASTM in accordance with ISO 14025:** **Internal** **External** **X**	Timothy Brooke ASTM International 100 Barr Harbor Dr. West Conshohocken, PA 19428 tbrooke@astm.org
EPD Project Report Information	
EPD Project Report	A Regionalized Industry-Average Cradle-to-Gate LCA of Precast Concrete Products Produced by CPCI Members, December 2022
Prepared by Athena Sustainable Materials Institute	Athena Sustainable Materials Institute 119 Ross Avenue, Suite 100 Ottawa, Ontario, Canada K1Y 0N6 info@athenasmi.org
This EPD project report was independently verified by in accordance with ISO 14025 and the reference PCR:	Thomas P. Gloria, Ph. D. Industrial Ecology Consultants 35 Bracebridge Rd. Newton, MA 02459-1728 t.gloria@industrial-ecology.com
This EPD was prepared using Athena Institute's pre-verified EPD Concrete Tool v2 (February 2022)	
PCR Information	
Program Operator	NSF and ASTM International
Reference PCR	NSF PCR for Precast Concrete, V3.0, May 2021[5]
PCR review was conducted by:	Dr. Thomas Gloria, Industrial Ecology Consultants Mr. Bill Stough, Bill Stough, LCC Dr. Michael Overcash, Environmental Clarity

1 PRODUCT IDENTIFICATION

1.1 PRODUCT DEFINITION

Precast concrete (UN CPC 3755) is a construction product produced by casting concrete in a reusable mold or "form" which is then cured in a controlled environment, transported to the construction site, and lifted into place. In contrast, standard concrete is placed into site-specific forms and cured on site. Precast concrete is primarily composed of portland cement, aggregates, and steel reinforcement materials. The applicable Canadian product standard for precast concrete products is CSA 23.4 Precast Concrete – Materials and Construction

For the purposes of this EPD the following broad descriptive definition for structural precast is as follows [5]:

Structural precast products: superstructure bridge products such as bridge decks, girders, and parapets; substructure bridge products such as abutments, piers, footings, and pile caps; building products such as columns, beams, interior solid bearing and shear walls, double tees, hollow core, spandrels, and solid slabs; stairs and stadia seating; and other items such as piles, footings, barriers, retaining walls, rail ties, sound walls and the like. Structural precast products can be conventionally reinforced or prestressed.

This EPD represents a baseline for the Canadian structural precast industry and exemplifies an average product group as an average from more than one manufacturer. Further, this EPD reports regional results as follows: ***Western Canada*** (BC, AB, SK and MN), ***Central Canada*** (ON) and ***Eastern Canada*** (QC, NB, NS, PEI and NFLD).

2 PRODUCT APPLICATION

Structural precast concrete products are engineered products satisfying a wide array of building and civil engineering applications.

3 DECLARED UNIT

The declared unit is 1 metric tonne of structural precast.

4 MATERIAL CONTENT

Table 1 below presents the regional weighted average material content by input material for the structural precast product group as derived from participating member facilities LCI data for the timeline 2021.

Table 1: Material Content for Structural Precast Product Groups

Inputs	Structural Precast - Eastern Region Ingredients (kg/tonne)	Structural Precast - Western Region Ingredients (kg/tonne)	Structural Precast - Central Region Ingredients (kg/tonne)
Cement			
Portland Cement	156.37	193.76	138.29
Aggregate			
Crushed Coarse Aggregate	348.16	396.08	380.42
Natural Fine Aggregate	126.08	303.68	306.84
Crushed Fine Aggregate	231.86	0.00	17.31
Natural Coarse Aggregate	7.51	0.00	0.00
SCMs			
Slag Cement	0.00	0.00	37.40
Fly Ash	17.36	3.30	0.00
Silica Fume	10.01	0.00	0.00
Mineral Fillers	0.00	0.00	3.76
Other Materials			
Rebar	3.00	27.89	11.56
Steel Stressing Strand	0.00	5.08	3.66
Steel Anchors	0.00	3.48	2.14
Welded Wire Reinforcement	0.00	2.54	0.24
Admixtures/form release agents (L)	1.48	1.62	2.07

5 PRODUCTION STAGE

Figure 1 shows the production stage system boundary for the declared product system.

PRODUCTION STAGE			CONSTRUCTION STAGE		USE STAGE							END OF LIFE STAGE			
Extraction and upstream production	Transport to Factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / Demolition	Transport	Waste Processing	Disposal of Waste
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

Figure 1 Production stage system boundary

The Production Stage includes the following processes [5]:

- A1 - Extraction and processing of raw materials, including fuels used in product production and transport within the manufacturing process (A3);
- A2 - Average or specific transportation of raw materials from the extraction site or source to manufacturing site, inclusive of empty backhauls (where applicable);
- A3 - Manufacturing of each precast product including all energy and materials required and all emissions and wastes produced;
- Average or specific transportation from manufacturing site to recycling/reuse/landfill for pre-consumer wastes and unutilized by-products from manufacturing, including empty backhauls (where applicable); and
- Final disposition of pre-consumer wastes inclusive of transportation.

The Production Stage excludes the following processes [5]:

- Production, manufacture, and construction of manufacturing capital goods and infrastructure;
- Formwork;
- Production and manufacture of production equipment, delivery vehicles, and laboratory equipment;
- Personnel related activities (travel, office operations and supplies); and
- Energy and water use related to company management and sales activities that may be located either within the factory site or at another location.

6 LIFE CYCLE INVENTORY

6.1 DATA COLLECTION AND REPRESENTATIVENESS

Life cycle inventory data were collected from 24 facilities within Canada for the 2021 reference year – representing slightly less than 40% of CPCI's membership. In total the participating facilities produced in the order of 5.5 million metric tonnes of precast products not all of which were structural precast.

All gate-to-gate LCI flow data for energy, total water use, emissions and waste generated were averaged on the annual production basis across facilities to determine an overall per unit precast plant operations profile. These per unit gate-to-gate operational flows were used to estimate the plant production effects across all precast product groups as plants were unable to provide detailed process breakdowns for each product type but provided annual product group production figures. Each plant also provided averaged formulation data for each product group they produce, and these data too were also averaged on a production weighted basis, but only across plants producing the precast product of interest; in this case structural precast. All hardware (lifting or connection) is included. These product formulations were also reviewed by CPCI's technical marketing group for plausibility (e.g., water to cement ratio, etc.)

6.2 SECONDARY LCI DATA A1-A3

Flow Ref.	Materials	LCI Data Source	Year / Region	Data Quality Assessment
A1-1	GU Cement *ASTM C150, C1157*	Calculated based on EPD data for specific suppliers	2021-2022 Canada	• Technology: very good • Time: very good • Geography: very good • Completeness: very good • Reliability: very good
A1-2	Fly Ash *ASTM C618*	None, no incoming burden, only transport is considered	N/A	• N/A • Recovered material
A1-3	Silica Fume *ASTM c1240*	None, no incoming burden, only transport is considered	N/A	• N/A • Recovered material
A1-4	Slag Cement *ASTM C989*	Slag Cement Association EPD of North America Slag Cement (2021)	2021 North America	• Technology: very good • Time: very good • Geography: very good • Completeness: very good • Reliability: very good

Flow Ref.	Materials	LCI Data Source	Year / Region	Data Quality Assessment
A1-5	Crushed Aggregates *coarse and fine* *ASTM C33*	ecoinvent 3.4: "Gravel, crushed {RoW}| production | Cut-off, U" (2018) Modified foreground process with region-specific electricity grid.	2001 World/ Regional	• Technology: very good • Time: poor • Geography: good • Completeness: very good • Reliability: very good
A1-6	Natural Aggregates *coarse and fine* *ASTM C330*	ecoinvent 3.4: "Gravel, round {RoW}| gravel and sand quarry operation | Cut-off, U" (2018) Modified foreground process with region-specific electricity grid.	2001 World/ Regional	• Technology: very good • Time: poor • Geography: good • Completeness: very good • Reliability: very good
A1-7	Pelletized Slag	Slag Cement Association EPD of North America Slag Cement, Module A1 (2021)	2021 North America	• Technology: very good • Time: very good • Geography: very good • Completeness: very good • Reliability: very good
A1-8	Admixtures *ASTM C494*	EFCA EPDs for Air Entrainers, Plasticisers and superplasticisers, Hardening Accelerators, Set Accelerators, Water Resisting Admixtures, and Retarders (2015) Non-supported LCIA indicators estimated – adjusted using TRACI equivalents	2015 EU	• Technology: very good • Time: very good • Geography: fair • Completeness: good • Reliability: very good
A1-9	Batch and Wash Water *ASTM C1602*	ecoinvent 3.4: Tap water {RoW}| market for | Cut-off, U (2018) Modified foreground process with Canada average electricity grid	2011 World/ USA	• Technology: very good • Time: good • Geography: good • Completeness: very good • Reliability: very good
A1-10	Steel Stressing Strand and Steel Anchors	American Iron and Steel Institute – Life Cycle Inventories of North American Steel Products (2020) - Hot-dip galvanized coil (HDG)	2017 USA	• Technology: very good • Time: very good • Geography: good • Completeness: very good • Reliability: very good

Flow Ref.	Materials	LCI Data Source	Year / Region	Data Quality Assessment
A1-11	Rebar, Welded Wire*	Concrete Reinforcing Steel Institute EPD for Steel Reinforcement Bar (2020) – *Adjusted by factor 1.10 for Welded Wire	2022 North America	• Technology: very good • Time: very good • Geography: good • Completeness: very good • Reliability: very good
A2-1	Road	USLCI 2014: Transport, combination truck, short-haul, diesel powered/tkm/RNA (2014) [13]	2010 USA	• Technology: very good • Time: good • Geography: very good • Completeness: very good • Reliability: very good
A2-2	Rail	USLCI 2014: Transport, train, diesel powered /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good
A2-3	Ocean	USLCI 2014: Transport, ocean freighter, average fuel mix /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good
A2-4	Barge	USLCI 2014: Transport, barge, average fuel mix /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good
A3-1	Electricity	ecoinvent 3.4: Electricity, low voltage {XX}| market for | Cut-off, U (2018) [18] Modeled based on provincial-specific electricity grids	2015 CAN	• Technology: very good • Time: very good • Geography: very good • Completeness: very good Reliability: very good
A3-2	Natural Gas	USLCI 2014: Natural Gas, combusted in industrial boiler /US U (2014)	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good
A3-3	Diesel	USLCI 2014: Diesel, combusted in industrial equipment /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good Reliability: very good

Flow Ref.	Materials	LCI Data Source	Year / Region	Data Quality Assessment
A3-4	Gasoline	USLCI 2014: Gasoline, combusted in equipment /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good
A3-5	Liquefied Propane Gas	USLCI 2014: Liquefied petroleum gas, combusted in industrial boiler /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good
A3-6	Hazardous Solid Waste,	ecoinvent 3.4: Hazardous waste, for incineration {RoW}| treatment of hazardous waste, hazardous waste incineration | Alloc Rec, U (2018) [18] Modified foreground process with Canada average electricity grid	2011 World/ USA	• Technology: very good • Time: good • Geography: good • Completeness: very good • Reliability: very good
A3-7	Non-Hazardous Solid Waste	ecoinvent 3.4: Inert waste {RoW}| treatment of, sanitary landfill | Alloc Rec, U (2018) [18] Modified foreground process with United States average electricity grid	2011 World/ USA	• Technology: very good • Time: good • Geography: good • Completeness: very good • Reliability: very good

6.3 CUT OFF RULES, ALLOCATION RULES AND DATA QUALITY REQUIREMENTS

Cut-off rules, as specified in NSF PCR for precast concrete: 2021, Section 7.1.8 were applied [5]. All input/output flow data reported by the participating member facilities were included in the LCI modeling. None of the reported flow data were excluded based on the cut-off criteria. No substances with hazardous and toxic properties that pose a concern for human health and/or the environment were identified in the framework of this EPD.

Allocation procedures observed the requirements and guidance of ISO 14044:2006, clause 4.3 and those specified in NSF PCR for precast concrete, section 7.1. The majority of the precast facility operations were dedicated to the production of one or more precast product groups. A small number of the facilities also produced other specialty precast products – a co-product - and in such instances “mass” allocation was used to allocate facility LCI environmental flows (inputs and outputs) across the co-products for those facilities prior to calculating and rolling up the weighted average LCI flows for the gate-to-gate process and individual product groups.

In addition, the following allocation rules are applied:

- Allocation related to transport is based on the mass and distance of transported inputs;
- The NSF sub-category PCR recognizes fly ash, silica fume and granulated bast furnace slag as recovered materials and thus the environmental impacts allocated to these materials are limited to the treatment and transportation required to use as a precast concrete material input. That is, any allocations before reprocessing are allocated to the original product;
- The environmental flows related to the disposal of the manufacturing (pre-consumer) solid and liquid waste are allocated to module A3 Manufacturing.

Data quality requirements, as specified in NSF's Precast Concrete PCR: 2021, section 7.1.9, were observed [5]. This section also describes the achieved data quality relative to the ISO 14044:2006 requirements. Data quality is judged on the basis of its precision (measured, calculated or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied within a study serving as a data source) and representativeness (geographical, temporal, and technological).

Precision: The Canadian participating member companies through measurement and calculation collected primary data on their production of precast concrete and the various sub-group product categories. For accuracy the LCA team individually validated these plant gate-to-gate input and output data.

Completeness: All relevant, specific processes, including inputs (raw materials, energy and ancillary materials) and outputs (emissions and production volume) were considered and modeled to represent industry average precast concrete. The relevant background materials and processes were taken from the US LCI Database, ecoinvent v 3.4 LCI database for Canada, United States and/or global and modeled in Athena's pre-verified Concrete LCA Software v2 (February 2022).

Consistency: To ensure consistency, the LCI modeling of the production weighted input and output LCI data for each regional precast product used the same modeling structure across the member facilities producing these products, which consisted of input raw and ancillary material, energy flows, water resource inputs, product and co-products outputs, emissions to air, water and soil, and material recycling and pre-consumer solid and liquid waste treatment. Crosschecks concerning the plausibility of mass and energy flows were continuously conducted. The LCA team conducted mass and energy balances at the plant and selected process level to maintain a high level of consistency.

Reproducibility: Internal reproducibility is possible since the data and the models are stored and available in CPCI Precast Athena LCI database developed in Athena's pre-verified Concrete LCA Software v2. A high level of transparency is provided throughout the LCA background report (publicly available) as the weighted average LCI profile for each product sub-group is presented for the declared product. Key primary (manufacturer specific) and secondary (generic) LCI data sources are also summarized in the LCA background report. The provision of more detailed data to allow full external reproducibility was not possible due to reasons of confidentiality.

Representativeness: The representativeness of the data is summarized as follows.

- ***Time related coverage*** of the precast manufacturing process - primary data collected: 2021 (12 months).
- Generic data: the most appropriate LCI datasets were used as found in the US LCI (adjusted) Database, ecoinvent v.3.4 database for United States, Canada and global.
- Sector specific data: each regional structural precast profile is based on plant specific cement production EPDs as used at each regional precast plant.
- ***Geographical coverage***: the geographical coverage is Canada (various regions).
- ***Technological coverage***: typical or average.

7 LIFE CYCLE ASSESSMENT

7.1 RESULTS OF THE LIFE CYCLE ASSESSMENT

This section summarizes the results of the life cycle impact assessment (LCIA) based on the cradle-to-gate life cycle inventory inputs and outputs analysis. The regional results are calculated on the basis of one metric tonne (1,000 kg) of structural precast (Tables 2-4). The structural precast production results are delineated by information module (A1 – Raw material supply), (A2 – Raw material transport), and (A3 – precast core manufacturing). Tables 5-6 represent the minimum and maximum values for insulated precast panel concrete.

As per NSF PCR for precast concrete:2021, Section 7.3, the US EPA Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI), version 2.1, 2012 impact categories are used as they provide a North American context for the mandatory category indicators to be included in this EPD. These are relative expressions only and do not predict category impact end-points, the exceeding of thresholds, safety margins or risks. Total primary and sub-set energy consumption was compiled using a cumulative energy demand model. Material resource consumption and generated waste reflect cumulative life cycle inventory flow information. In addition, some LCA impact categories and inventory items are still under development and can have high levels of uncertainty and demarked with an "*". To promote uniform guidance on the data collection, calculation and reporting of results, the ACLCA methodology guidance (ACLCA 2019) was used [6].

Table 2: LCA results – Structural Precast, one metric ton - Western Region

Impact category and inventory indicators	Unit	Module A1	Module A2	Module A3	Total (A1-A3)
Environmental impact Indicators					
Global warming potential (GWP)	kg CO2 eq.	203.30	11.74	65.08	280.11
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 eq.	4.42E-06	4.93E-10	5.08E-07	4.93E-06
Eutrophication potential (EP)	kg N eq.	0.22	0.01	0.16	0.39
Acidification potential of soil and water sources (AP)	kg SO2 eq.	1.27	0.14	0.46	1.88
Formation potential of tropospheric ozone (POCP)	kg O3 eq.	13.14	3.64	2.56	19.35
Use of primary resources					
Renewable primary energy resources as energy (fuel), (RPRE)*	MJ, NCV	120.23	0.00	57.97	178.20
Renewable primary resources as material, (RPRM)*	MJ, NCV	0.00	0.00	0.00	0.00
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	1290.40	177.52	1034.73	2502.66
Non-renewable primary resources as material (NRPRM)*	MJ, NCV	0.00	0.00	0.00	0.00
Use of secondary resources					
Secondary Materials, (SM)*	kg	0.00	0.00	0.00	0.00
Renewable secondary fuels, (RSF)*	MJ, NCV	0.00	0.00	0.00	0.00
Non-renewable secondary fuels (NRSF)*	MJ, NCV	0.00	0.00	0.00	0.00
Recovered energy, (RE)*	MJ, NCV	0.00	0.00	0.00	0.00
Abiotic depletion potential					
Abiotic depletion potential for fossil resources (ADPfossil)*	MJ, LHV	594.48	167.47	935.71	1697.65
Abiotic depletion potential for non-fossil mineral resources (ADPelements)*	kg Sb	2.95E-04	0.00E+00	1.36E-05	3.08E-04
Consumption of freshwater resources					
Consumption of fresh water	m3	0.60	0.00	0.93	1.53
Waste and output flows					
Hazardous waste disposed*	kg	0.04	0.00	0.21	0.25
Non-hazardous waste disposed*	kg	5.48	0.00	0.01	5.49
High-level radioactive waste*	m3	1.50E-05	0.00E+00	4.59E-09	1.50E-05
Intermediate and low-level radioactive waste*	m3	4.14E-04	0.00E+00	1.97E-08	4.14E-04
Components for reuse*	kg	0.00	0.00	0.00	0.00
Materials for recycling*	kg	0.00	0.00	0.00	0.00
Materials for energy recovery*	kg	0.00	0.00	0.00	0.00
Recovered energy exported from the product system*	kg	0.00	0.00	0.00	0.00
Additional inventory parameters for transparency					
CO_2 emissions from calcination*	kg CO2 eq.	85.21	0.00	0.00	85.21

Table 3: LCA results- Structural Precast, one metric ton - Eastern Region

Impact category and inventory indicators	Unit	Module A1	Module A2	Module A3	Total (A1-A3)
Environmental impact Indicators					
Global warming potential (GWP)	kg CO2 eq.	171.93	16.95	34.49	223.37
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 eq.	3.15E-06	7.16E-10	4.66E-07	3.62E-06
Eutrophication potential (EP)	kg N eq.	0.13	0.01	0.03	0.17
Acidification potential of soil and water sources (AP)	kg SO2 eq.	0.71	0.20	0.22	1.13
Formation potential of tropospheric ozone (POCP)	kg O3 eq.	10.32	5.01	1.74	17.07
Use of primary resources					
Renewable primary energy resources as energy (fuel), (RPRE)*	MJ, NCV	72.81	0.00	68.19	141.00
Renewable primary resources as material, (RPRM)*	MJ, NCV	0.00	0.00	0.00	0.00
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	463.35	257.87	472.90	1194.12
Non-renewable primary resources as material (NRPRM)*	MJ, NCV	0.00	0.00	0.00	0.00
Use of secondary resources					
Secondary Materials, (SM)*	kg	0.00	0.00	0.00	0.00
Renewable secondary fuels, (RSF)*	MJ, NCV	0.00	0.00	0.00	0.00
Non-renewable secondary fuels (NRSF)*	MJ, NCV	0.00	0.00	0.00	0.00
Recovered energy, (RE)*	MJ, NCV	0.00	0.00	0.00	0.00
Abiotic depletion potential					
Abiotic depletion potential for fossil resources (ADPfossil)*	MJ, LHV	62.28	243.27	430.20	735.75
Abiotic depletion potential for non-fossil mineral resources (ADPelements)*	kg Sb	4.61E-05	0.00E+00	5.55E-06	5.17E-05
Consumption of freshwater resources					
Consumption of fresh water	m3	0.30	0.00	0.94	1.24
Waste and output flows					
Hazardous waste disposed*	kg	0.01	0.00	2.28	2.29
Non-hazardous waste disposed*	kg	0.06	0.00	0.00	0.06
High-level radioactive waste*	m3	1.47E-06	0.00E+00	6.87E-09	1.47E-06
Intermediate and low-level radioactive waste*	m3	4.03E-05	0.00E+00	2.75E-08	4.04E-05
Components for reuse*	kg	0.00	0.00	0.00	0.00
Materials for recycling*	kg	0.00	0.00	0.00	0.00
Materials for energy recovery*	kg	0.00	0.00	0.00	0.00
Recovered energy exported from the product system*	kg	0.00	0.00	0.00	0.00
Additional inventory parameters for transparency					
CO_2 emissions from calcination*	kg CO2 eq.	87.82	0.00	0.00	87.82

Table 4: LCA results- Structural Precast, one metric ton - Central Region

Impact category and inventory indicators	Unit	Module A1	Module A2	Module A3	Weighted Average Total
Environmental impact Indicators					
Global warming potential (GWP)	kg CO2 eq.	164.64	9.26	34.90	208.80
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 eq.	3.13E-06	3.90E-10	5.72E-07	3.70E-06
Eutrophication potential (EP)	kg N eq.	0.10	0.01	0.02	0.13
Acidification potential of soil and water sources (AP)	kg SO2 eq.	1.13	0.11	0.22	1.46
Formation potential of tropospheric ozone (POCP)	kg O3 eq.	12.49	2.83	1.72	17.04
Use of primary resources					
Renewable primary energy resources as energy (fuel), (RPRE)*	MJ, NCV	119.29	0.00	21.84	141.12
Renewable primary resources as material, (RPRM)*	MJ, NCV	0.00	0.00	0.00	0.00
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	753.24	140.36	639.79	1533.38
Non-renewable primary resources as material (NRPRM)*	MJ, NCV	0.00	0.00	0.00	0.00
Use of secondary resources					
Secondary Materials, (SM)*	kg	0.00	0.00	0.00	0.00
Renewable secondary fuels, (RSF)*	MJ, NCV	0.00	0.00	0.00	0.00
Non-renewable secondary fuels (NRSF)*	MJ, NCV	0.00	0.00	0.00	0.00
Recovered energy, (RE)*	MJ, NCV	0.00	0.00	0.00	0.00
Abiotic depletion potential					
Abiotic depletion potential for fossil resources (ADPfossil)*	MJ, LHV	195.42	132.41	439.69	767.53
Abiotic depletion potential for non-fossil mineral resources (ADPelements)*	kg Sb	2.16E-04	0.00E+00	1.23E-05	2.29E-04
Consumption of freshwater resources					
Consumption of fresh water	m3	0.78	0.00	1.23	2.01
Waste and output flows					
Hazardous waste disposed*	kg	0.02	0.00	2.61	2.63
Non-hazardous waste disposed*	kg	70.69	0.00	0.00	70.69
High-level radioactive waste*	m3	5.83E-06	0.00E+00	6.20E-07	6.45E-06
Intermediate and low-level radioactive waste*	m3	1.61E-04	0.00E+00	4.56E-07	1.61E-04
Components for reuse*	kg	0.00	0.00	0.00	0.00
Materials for recycling*	kg	0.00	0.00	0.00	0.00
Materials for energy recovery*	kg	0.00	0.00	0.00	0.00
Recovered energy exported from the product system*	kg	0.00	0.00	0.00	0.00
Additional inventory parameters for transparency					
CO_2 emissions from calcination*	kg CO2 eq.				

Table 5: Maximim Values for Structural Precast Concrete

Impact category and inventory indicators	Unit	Western Structural	Eastern Structural	Central Structural
Environmental impacts				
Global warming potential (GWP)	kg CO2 eq.	291.84	239.93	220.90
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 eq.	5.35E-06	3.92E-06	4.00E-06
Eutrophication potential (EP)	kg N eq.	0.39	0.24	0.16
Acidification potential of soil and water sources (AP)	kg SO2 eq.	1.90	1.14	1.47
Formation potential of tropospheric ozone (POCP)	kg O3 eq.	20.24	18.05	18.09
Abiotic depletion potential for fossil resources (ADPfossil)*	MJ, LHV	1710.61	739.66	757.56

Table 6: Minimum Values for Structural Precast Concrete

Impact category and inventory indicators	Unit	Western Structural	Eastern Structural	Central Structural
Environmental impacts				
Global warming potential (GWP)	kg CO2 eq.	268.38	206.81	196.70
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 eq.	4.50E-06	3.32E-06	3.40E-06
Eutrophication potential (EP)	kg N eq.	0.38	0.10	0.09
Acidification potential of soil and water sources (AP)	kg SO2 eq.	1.86	1.12	1.45
Formation potential of tropospheric ozone (POCP)	kg O3 eq.	18.46	16.08	16.00
Abiotic depletion potential for fossil resources (ADPfossil)*	MJ, LHV	1684.69	731.83	777.50

7.2 INTERPRETATION

Across the three production information modules, module A1- raw material supply contributes the largest share of the impact category results. The upstream raw material supply (A1) also accounts for a large share of energy use; almost all of which is drawn from non-renewable energy sources. Raw material transportation (A2) proves to be a minor contributor to the burdens exhibited by structural precast products – generally 10% or less. Manufacturing (A3) structural precast products contributes in the order of 15% of all greenhouse gases and about 40% of the primary energy use.

The significance of these results is as follows:

- Raw material supply (upstream material effects) is the major source of the environmental impacts of precast products and is significantly influenced by cement use – efforts to optimize or reduce the input of cement by using less burdensome cement blends or increasing supplementary cementitious materials use would markedly improve the environmental performance of all precast products.
- As the manufacturing stage is a substantial consumer of energy and responsible for a significant share of the impacts, any process or energy conservation improvements would directly and significantly lower the environmental profile of precast products.

8 ADDITIONAL ENVIRONMENTAL INFORMATION

Quality and Environmental Management Systems

In general, CPCI member manufacturing facilities follow the ISO 14001 environmental management system, ISO 9001 quality management system or other in-house quality control systems.

9 DECLARATION TYPE AND PRODUCT AVERAGE DECLARATION

The type of EPD is defined as:

A “Cradle-to-gate” EPD of structural precast covering the product stage (modules A1 to A3) and is intended for use in Business-to-Business communication.

This EPD for structural precast, UN CPC 3755 is an average product EPD, as an average from several CPCI member facilities in various regions of the country.

10 DECLARATION COMPARABILITY LIMITATION STATEMENT

The following ISO statement indicates the EPD comparability limitations and intent to avoid any market distortions or misinterpretation of EPDs based on the NSF's Precast Concrete PCR: 2021:

- EPDs from different programs (using different PCR) may not be comparable.

- Declarations based on the NSF Precast Concrete PCR [5] are not comparative assertions; that is, no claim of environmental superiority may be inferred or implied.

11 EPD EXPLANATORY MATERIAL

For any explanatory material, in regard to this EPD, please contact the program operator.

ASTM International
Environmental Product Declarations
100 Barr Harbor Drive,
West Conshohocken,
PA 19428-2959, http://www.astm.org

12 REFERENCES

1. ISO 21930: 2017 Building construction – Sustainability in building construction – Environmental declaration of building products.
2. ISO 14025: 2006 Environmental labeling and declarations - Type III environmental declarations - Principles and procedures.
3. ISO 14044: 2006 Environmental management - Life cycle assessment - Requirements and guidelines.
4. ISO 14040: 2006 Environmental management - Life cycle assessment - Principles and framework.
5. NSF PCR for Precast Concrete, V3.0, May 2021.
6. American Center for Life-Cycle Assessment (ACLCA) 2019, ACLCA Guidance to Calculating Non-LCIA Metrics in Accordance with ISO21930:2017 https://aclca.org/aclca-iso-21930-guidance/

Appendix A – Participating Plant List

Anchor Concrete Products
1645 Sydenham Road
Kingston, Ontario
K7L 4V4
www.anchorconcrete.com/

locations: Kingston, Ontario

Bétons Préfabriqués Du Lac Inc.
890 Rue de Pins O
Alma, Québec
G8B 7R3
www.bpdl.com

locations: Alma, Québec

Centura Building Systems
460 Fraser View Pl
Delta, BC
V3M 6H4
www.centurabuilding.com

locations: Delta, British Columbia

Con-force Structures
7900 Nelson Rd
Richmond, BC
V6W 1G4
www.conforcestructures.com

locations: Richmond, British Columbia

Central Precast
25 Bongard Avenue
Nepean, Ontario
K2E 6V2
www.centralprecast.com

locations: Nepean, Ontario

DECAST Ltd.
8807 Simcoe County Road
Utopia, Ontario
L0M 1T0
www.decastltd.com

locations: Utopia, Ontario

Eagle Builders LP
27322-17 TWP Road Aspelund
Industrial Park
Blackfalds, Alberta
T0M 0J0
www.eaglebuilders.ca

locations: Blackfalds, Alberta

Ed's Concrete Product Ltd.
1266 Erie Street
Stratford, Ontario
N4Z 0A1
www.edsconcrete.ca

locations: Stratford, Ontario

Lafarge Precast Edmonton Alberta
14425 92 Avenue, NW
Edmonton, Alberta
T6B 2J4
www.lafargeprecastedmonton.com

locations: Edmonton, Alberta

Lafarge Pipe, Precast, & Hollow-core
185 Dawson Road N
Winnipeg, Manitoba
R2J 0S6
www.lafarge.ca

locations: Winnipeg, Manitoba

Mardina Construction
1083 Appel Road
Agassiz, British Columbia
V0M 1A2
www.mardina.ca

locations: Agassiz, British Columbia

Power Precast Solutions
5598 Power Road
Ottawa, Ontario
K1G 3N4
www.powerprecast.com

locations: Ottawa, Ontario

Proform Concrete
240 Burnt Park Way
Red Deer County, AB
T4S 2L4
www.proform.ca

locations: Red Deer, Alberta

Patio Drummond
8435 Bd Saint-Joseph
Saint-Nicéphore, QC
J2A 3W8
www.patiodrummond.com

locations: Saint- Nicéphore, Québec

Pre-Con Ltd.
3320 Idylwyld Drive N
Saskatoon, Saskatchewan
S7L 5Y7
www.preconltd.ca

locations: Saskatoon, Saskatchewan

Prestressed Systems, Inc.
4955 Walker Road
Windsor, Ontario
N9A 6J3
www.theprecaster.com

locations: Windsor, Ontario

Rapid-Span Structures Ltd.
1145 Industrial Drive
Armstrong, British Columbia
V0E 1B6
www.rapidspan.com

locations: Armstrong, British Columbia

Souris Valley Industries
Intersection 13 & 19, Range Road, 2150 Hwy 39
Weyburn, Saskatchewan
S4H 2K3
www.sviprecast.com

locations: Weyburn, Saskatchewan

Strescon
131 Duke Street
Bedford, Nova Scotia
B4A 3C3
www.oscoconstructiongroup.com

locations: Bedford, Nova Scotia

Stubbe's Precast
44 Muir Line
Harley, Ontario
N0E 1E0
www.stubbes.org

locations: Harley, Ontario

TKL Group
1 152 Toryork Drive
North York, Ontario
M9L 1X6
www.tklgroup.com

locations: North York, Ontario

Tri-Kon Precast Products Ltd.
601 Patterson Street W
Cranbrook, British Columbia
V1C 6T3
www.trikonprecast.com

locations: Cranbrook, British Columbia