Acton Precast Concrete Limited
Manufacturers since 1963

Acton Precast Concrete Ltd.
Precast Concrete Environmental Product Declaration

According to ISO 14025:2006 and ISO 21930:2017

ASTM INTERNATIONAL
Helping our world work better

An Environmental Product Declaration

In accordance with ISO 14025 and 21930

About this EPD

This is a Type III environmental product declaration (EPD) for precast concrete as produced by Acton Precast Concrete Ltd. (Acton Precast) at its facility located in Acton, Ontario. The results of the underlying LCA are computed using the North American (N.A.) version of the Global Cement and Concrete Association (GCCA) Industry EPD Tool for cement and concrete [1]. This tool and the underlying LCA model and database [2] have been previously verified to conform to the prevailing sub-product category rule (PCR) [3], ISO 21930:2017 (the core PCR) [4] as well as ISO 14020:2000 [5] and ISO 14040/44:2006 LCA standards [6], [7].

This EPD is certified by ASTM to conform to the sub-Product Category Rule (PCR) referenced above [3], as well as to the requirements of ISO 14020 [5], ISO 14025 [8], ISO 21930 and ASTM International's General Program Instructions [9]. This EPD is intended for business-to-business audiences.

General Summary

EPD Commissioner and Owner Acton Precast Concrete Limited Manufacturers since 1963	**Acton Precast Concrete Ltd.** 8949 Wellington County Road 50 Acton, Ontario. L7J 2L8 https://actonprecast.com/ Acton Precast company personnel provided LCI and meta data for the 2023 reference year in support of this EPD. *The owner of the declaration is liable for the underlying information and evidence*.
Product Group and Name	*Precast Concrete, UN CPC 37550.*
Product Definition	**Precast concrete** is a construction product manufactured 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. Precast concrete is used in building or civil engineering works and is primarily composed of cement, aggregates, and reinforcement materials.
Product Category Rules (PCR)	NSF International, Product Category Rules for Preparing an Environmental Product Declaration for Precast Concrete, V3.0, May 2021 [3].
Date of Issue & Validity Period	May 17, 2024 – 5 years
Declared Unit	1 metric ton of precast concrete

EPD and Project Report Information

Program Operator	ASTM International
Declaration Number	EPD 710
Declaration Type	Cradle-to-gate (modules A1 to A3). Facility and product-specific.
Applicable Countries	Canada
Product Applicability	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 International, Product Category Rules for Preparing an Environmental Product Declaration for Precast Concrete, V3.0, May 2021 [3].
This EPD was independently verified by ASTM in accordance with ISO 14025 and the reference PCR: Internal — **External** X	Tim Brooke ASTM International 100 Barr Harbor Drive PO Box C700 West Conshohocken PA 19428-2959, USA cert@astm.org Thomas P. Gloria, Ph. D. Industrial Ecology Consultants 35 Bracebridge Road Newton, MA 02459-1728
Notes	The EPD results reported herein are computed using the N.A. GCCA Industry EPD tool for Cement and Concrete (https://concrete-epd-tool.org) [1].
EPD Prepared by: Athena Sustainable Materials Institute	Kevin Garrahan and Jamie Meil Athena Sustainable Materials Institute 280 Albert Street, Suite 404 Ottawa, Ontario, Canada K1P 5G8 info@athenasmi.org www.athenasmi.org

PCR Information

Program Operator	NSF International
Reference PCR	Product Category Rules for Preparing an Environmental Product Declaration for Precast Concrete, V3.0, May 2021 [3].
PCR review was conducted by:	Thomas P. Gloria, PhD (Chair), Industrial Ecology Consultants, Mr. Jack Geibig, EcoForm Mr. Bill Stough, Sustainable Research Group

Product Description

This EPD reports environmental transparency information for precast concrete produced by Acton Precast. Precast concrete is a construction product manufactured 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, cast-in-place concrete is placed into site-specific forms and cured on site. Precast concrete is primarily composed of portland cement, aggregates, and steel reinforcement materials. This EPD covers three distinct categories of precast concrete products manufactured by Acton Precast. For the purposes of this EPD the following broad descriptive definitions for the three categories of precast concrete covered by this report are as follows:

Underground electrical vaults and bases: House electrical service infrastructure equipment, such as power cables, switch gears, and transformers for electrical infrastructure applications.

Above ground traffic blocks, wall blocks, and pads: Includes parking curbs, traffic barriers, and concrete blocks and pads for residential, commercial, and transportation infrastructure applications.

Underground water and septic tanks: Includes water-tight storage tanks for on site water storage and sewage treatment for residential and commercial applications.

Products and Standards

The applicable Canadian standard for precast concrete products is CSA 23.4 *Precast Concrete – Materials and Construction*.

Table 1 below presents the percent composition of Acton Precast's precast concrete products by input material as derived from facility LCI data for the 2023 reference year.

Table 1: Material content for Acton Precast precast concrete products (in %)

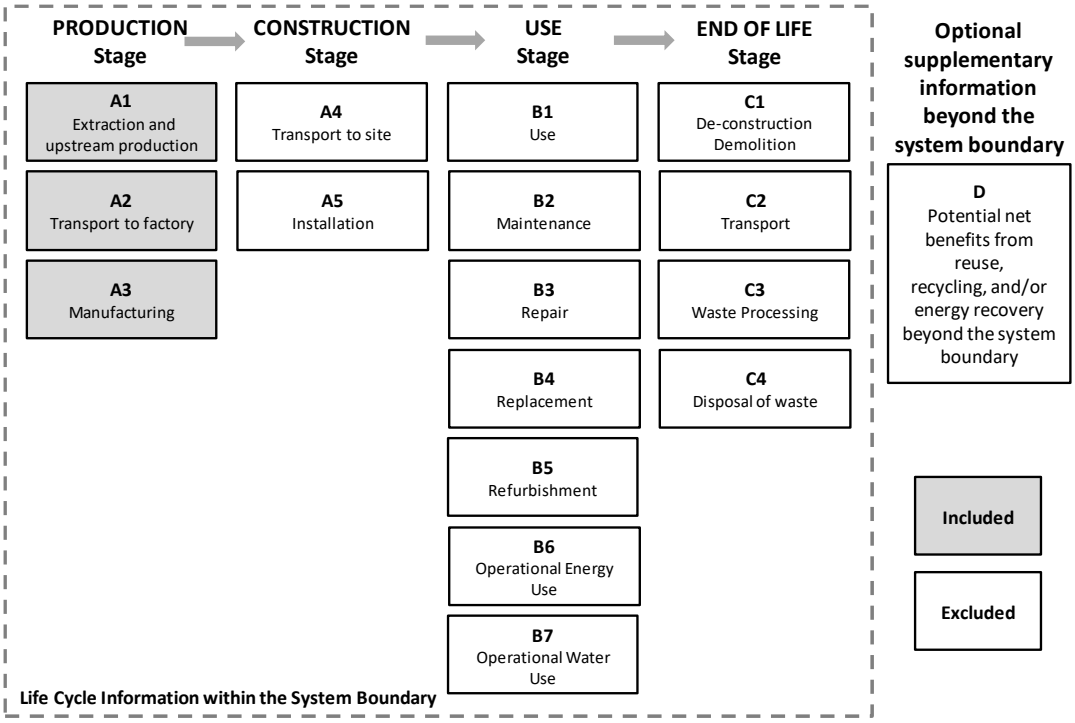
Inputs	Underground Electrical Vaults and Bases	Above Ground Traffic Blocks, Wall Blocks, and Pads	Underground Water and Septic Tanks
Coarse Aggregate	49.2%	49.8%	49.7%
Fine aggregate	27.5%	27.9%	27.8%
Portland Cement	12.2%	12.4%	12.4%
Water	5.8%	5.8%	5.8%
Slag Cement	2.8%	2.9%	2.9%
Reinforcing Steel and Anchors	2.4%	1.2%	1.4%
Chemical Admixtures	<0.1%	<0.1%	<0.1%
Total	100%	100%	100%

Declared Unit

The declared unit is one metric ton of precast concrete.

System Boundary

This is a cradle-to-gate EPD covering the production stage (A1-A3) as depicted in the figure below. The production stage includes extraction of raw materials (cradle) through the manufacture and transport of precast concrete ready for shipment (gate).



The production stage includes the following processes [3]:

- A1 shall include the constituents of concrete listed in NSF PCR Part A Table 1;
- A2 shall assume all long-haul transport by bulk carriers (greater than 322 km (200 mi)). Long-haul trucks do not typically return empty and thus can use the US LCI dataset which includes 35% additional distance to account for this;
- A2 shall assume that all short haul transport (local trucks and dump trucks) return empty. Thus, one way transport distance less than 322 km (200 mi) shall be multiplied by (2/1.35) to reflect two-way transport and eliminate the 35% additional distance included in the US LCI. This calculation is automatically applied to short haul transportation distances by the GCCA Tool;
- A3 shall include transportation activities at the concrete manufacturing site;
- A3 shall include ancillary materials which include, but are not limited to, lubricating oils, engine oils, & other consumable operations equipment maintenance (OEM) products;
- A3 shall include final end of life treatment for any manufacturing waste. For example, admixture and ancillary material packaging.

Items *excluded* from the system boundary include:

- 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.

Cut-off Criteria

The cut-off criteria per NSF PCR, Section 7.1.8 [3] and ISO 21930, 7.1.8 [4] were followed. Per ISO 21930, 7.1.8, all input/output data required were collected and included in the LCI modelling. 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. None of the reported flow data were excluded based on the cut-off criteria.

Data Collection

Life cycle inventory data was collected from Acton Precast for the 2023 reference year. In addition, this EPD draws on company specific EPDs within Acton Precast's supply chain for cement and reinforcing steel [10], [11].

Allocation Rules

Allocation procedures comply with the requirements and guidance of ISO 14044:2006 [7], clause 4.3, and the requirements specified in NSF PCR for Precast Concrete, Section 7.1 [3]. Acton Precast manufactured precast concrete products which are encompassed in the three product categories outlined above, as well as other precast concrete products during the 2023 reference year. The scope of this EPD is to model and report on the manufacturing of precast concrete within the three designated product categories and does not include other precast concrete products manufactured during the 2023 reference year.

Product-specific material inputs related to each category of precast concrete were collected from the manufacturer to eliminate the need for allocation of material inputs between the three product categories and other precast concrete production. Material inputs for each precast concrete category were normalized against the total annual production of the product category during the reference year to provide reference flows per metric ton of precast concrete product for each product category. Material inputs for other precast concrete products were not incorporated in the scope of this study.

Data for energy use (such as electricity usage, gasoline, diesel, etc.) and waste from manufacturing, were not provided separately for precast concrete product categories. Energy and waste flows were allocated by "mass" and normalized against the total precast concrete production (including all product categories and other precast concrete production) to provide reference energy and waste flows per metric ton of *total production*.

In addition, the following 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, blast furnace slag, and silica fume 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. 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 and Assessment

As specified in NSF PCR, Section 7.1.9 [3], and ISO 21930 Section 7.1.9 [4], appropriate activity and LCI foreground and background data shall be used to model the precast concrete product systems. LCI data should be as representative (technologically, geographically, and time-specific), complete, consistent, reproducible, and transparent as possible with regards to the goal and scope of the study [6], [7].

Primary LCI and meta-data for Acton Precast's precast concrete production was gathered for the 2023 reference year. For accuracy, the LCA team individually validated these gate-to-gate input and output data.

Since the GCCA Industry EPD Tool is pre-verified to meet the requirements of ISO 21930:2017 and the NSF PCR [3], the need to assess the background data was limited to upstream product-specific EPDs for cement and rebar [10], [11]. The product-specific EPD for cement is characterized as high representativeness for Technological, Geographical, and Time coverage. The product-specific EPD for rebar is characterized as *high* representativeness for Tehcnological and Geographical coverage, and *medium* representativeness for Time coverage.

Completeness:

All relevant, specific processes, including inputs (raw materials, energy, and ancillary materials) and outputs (emissions and production volume) were considered and modeled to complete production profile for Acton Precast's plant producing precast concrete.

Reproducibility:

Internal reproducibility is possible since the data and the model are stored and available in Athena's GCCA Tool database. The provision of more detailed data to allow for full external reproducibility is not possible due to reasons of confidentiality.

Transparency:

Activity and LCI datasets are transparently disclosed in the project report. A comprehensive list of secondary LCI datasets is available on the GCCA Tool website. Note: An account is required to access the GCCA Tool.

Uncertainty:

A sensitivity check was performed to assess the reliability of the EPD results and conclusions by determining how they are affected by uncertainties in the data or assumptions on calculations of LCIA and energy indicator results. The variation across significant inputs was found to be well within the expected range and hence there is a high degree of confidence in the results.

Life Cycle Impact Assessment Results: Acton Precast

This section summarizes the production stage life cycle impact assessment (LCIA) results including resource use and waste generated metrics based on the cradle-to-gate life cycle inventory inputs and outputs analysis. The results are calculated based on 1 metric ton of each precast concrete product category as manufactured by Acton Precast.

It should be noted that LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks [4], [7]. Further, many LCA impact categories and inventory items are still under development and have high levels of uncertainty. These impact categories and inventory items are marked with an asterisk "*".'

Table 2: Product Stage (A1-A3) EPD Results – 1 metric ton of precast concrete – Acton Precast – Underground Electrical Vaults and Bases

Impact category and inventory indicators	Unit	Acton Precast – Underground Electrical Vaults and Bases			
		A1	A2	A3	A1-A3 Total
Environmental impacts					
Global warming potential	kg CO_2 eq.	**140**	**11**	**17**	**168**
Global warming potential, biogenic	kg CO_2 eq.	**5.36E-02**	**6.10E-04**	**2.11E-02**	**7.53E-02**
Ozone depletion potential	kg CFC-11 eq.	**4.03E-06**	**3.90E-07**	**5.00E-08**	**4.48E-06**
Eutrophication potential	kg N eq.	**0.15**	**0.01**	**0**	**0.16**
Acidification potential	kg SO_2 eq.	**0.56**	**0.11**	**0.05**	**0.71**
Photochemical oxidant creation potential	kg O_3 eq.	**9.35**	**2.7**	**0.86**	**12.91**
Use of primary resources					
Renewable primary resources used as an energy carrier (fuel)*	MJ, LHV	**40**	**0**	**15**	**55**
Renewable primary resources with energy content used as material*	MJ, LHV	**0**	**0**	**0**	**0**
Non-renewable primary resources used as an energy carrier (fuel)*	MJ, LHV	**550**	**156**	**304**	**1010**
Non-renewable primary resources with energy content used as material*	MJ, LHV	**0**	**0**	**0**	**0**
Use of secondary resources					
Secondary materials*	kg	**44.73**	**0**	**0**	**44.73**
Renewable secondary fuels*	MJ, LHV	**0**	**0**	**0**	**0**
Non-renewable secondary fuels*	MJ, LHV	**135**	**0**	**0**	**135**
Abiotic depletion potential					
Abiotic depletion potential for non-fossil mineral resources*	kg Sb eq.	**6.61E-05**	**6.72E-06**	**5.70E-06**	**7.85E-05**
Abiotic depletion potential for fossil resources*	MJ, LHV	**465**	**156**	**304**	**926**
Consumption of freshwater resources					
Consumption of freshwater*	m^3	**1.59**	**0.01**	**0.27**	**1.86**
Waste and output flows					
Hazardous waste disposed*	kg	**0**	**0**	**0**	**0**
Non-hazardous waste disposed*	kg	**4.19**	**0**	**1.05**	**5.23**
High-level radioactive waste, conditioned, to final repository, HLRW*	kg	**x**[1)]	**x**[1)]	**x**[1)]	**x**[1)]
Intermediate and low-level radioactive waste, conditioned, to final repository, ILLRW*	kg	**x**[1)]	**x**[1)]	**x**[1)]	**x**[1)]
Components for reuse*	kg	**1.58**	**0**	**0**	**1.58**
Materials for recycling*	kg	**0.84**	**0**	**27.89**	**28.72**
Materials for energy recovery*	kg	**0**	**0**	**0**	**0**
Recovered energy exported from the product system*	MJ per energy carrier	**0**	**0**	**0**	**0**
Additional inventory parameters for transparency					
Emissions from calcination and removals from carbonation*	kg CO_2 eq.	**56.10**	**0**	**0**	**56.10**
Emissions from combustion of waste from non-renewable sources*	kg CO_2 eq.	**11.53**	**0**	**0**	**11.53**

Table 3: Product Stage (A1-A3) EPD Results – 1 metric ton of precast concrete – Acton Precast – Above Ground Traffic Blocks, Wall Blocks, and Pads

Impact category and inventory indicators	Unit	Acton Precast – Above Ground Traffic Blocks, Wall Blocks, and Pads			
		A1	A2	A3	A1-A3 Total
Environmental impacts					
Global warming potential	kg CO_2 eq.	**126**	**11**	**17**	**153**
Global warming potential, biogenic	kg CO_2 eq.	**5.42E-02**	**6.10E-04**	**2.11E-02**	**7.60E-02**
Ozone depletion potential	kg CFC-11 eq.	**4.10E-06**	**3.90E-07**	**5.00E-08**	**4.54E-06**
Eutrophication potential	kg N eq.	**0.15**	**0.01**	**0**	**0.16**
Acidification potential	kg SO_2 eq.	**0.49**	**0.11**	**0.05**	**0.65**
Photochemical oxidant creation potential	kg O_3 eq.	**8.38**	**2.7**	**0.86**	**11.93**
Use of primary resources					
Renewable primary resources used as an energy carrier (fuel)*	MJ, LHV	**28**	**0**	**15**	**43**
Renewable primary resources with energy content used as material*	MJ, LHV	**0**	**0**	**0**	**0**
Non-renewable primary resources used as an energy carrier (fuel)*	MJ, LHV	**351**	**156**	**304**	**811**
Non-renewable primary resources with energy content used as material*	MJ, LHV	**0**	**0**	**0**	**0**
Use of secondary resources					
Secondary materials*	kg	**35.03**	**0**	**0**	**35.03**
Renewable secondary fuels*	MJ, LHV	**0**	**0**	**0**	**0**
Non-renewable secondary fuels*	MJ, LHV	**137**	**0**	**0**	**137**
Abiotic depletion potential					
Abiotic depletion potential for non-fossil mineral resources*	kg Sb eq.	**7.03E-05**	**6.72E-06**	**5.70E-06**	**8.27E-05**
Abiotic depletion potential for fossil resources*	MJ, LHV	**280**	**156**	**304**	**740**
Consumption of freshwater resources					
Consumption of freshwater*	m^3	**1.57**	**0.01**	**0.27**	**1.84**
Waste and output flows					
Hazardous waste disposed*	kg	**0**	**0**	**0**	**0**
Non-hazardous waste disposed*	kg	**3.48**	**0**	**1.05**	**4.52**
High-level radioactive waste, conditioned, to final repository, HLRW*	kg	**x**[1)]	**x**[1)]	**x**[1)]	**x**[1)]
Intermediate and low-level radioactive waste, conditioned, to final repository, ILLRW*	kg	**x**[1)]	**x**[1)]	**x**[1)]	**x**[1)]
Components for reuse*	kg	**1.60**	**0**	**0**	**1.60**
Materials for recycling*	kg	**0.43**	**0**	**27.89**	**28.31**
Materials for energy recovery*	kg	**0**	**0**	**0**	**0**
Recovered energy exported from the product system*	MJ per energy carrier	**0**	**0**	**0**	**0**
Additional inventory parameters for transparency					
Emissions from calcination and removals from carbonation*	kg CO_2 eq.	**56.80**	**0**	**0**	**56.80**
Emissions from combustion of waste from non-renewable sources*	kg CO_2 eq.	**11.67**	**0**	**0**	**11.67**

Table 4: Product Stage (A1-A3) EPD Results – 1 metric ton of precast concrete – Acton Precast – Underground Water and Septic Tanks

Impact category and inventory indicators	Unit	Acton Precast – Underground Water and Septic Tanks			
		A1	A2	A3	A1-A3 Total
Environmental impacts					
Global warming potential	kg CO_2 eq.	**128**	**11**	**17**	**156**
Global warming potential, biogenic	kg CO_2 eq.	**5.41E-02**	**6.10E-04**	**2.11E-02**	**7.58E-02**
Ozone depletion potential	kg CFC-11 eq.	**4.08E-06**	**3.90E-07**	**5.00E-08**	**4.53E-06**
Eutrophication potential	kg N eq.	**0.15**	**0.01**	**0**	**0.16**
Acidification potential	kg SO_2 eq.	**0.50**	**0.11**	**0.05**	**0.66**
Photochemical oxidant creation potential	kg O_3 eq.	**8.55**	**2.7**	**0.86**	**12.11**
Use of primary resources					
Renewable primary resources used as an energy carrier (fuel)*	MJ, LHV	**30**	**0**	**15**	**46**
Renewable primary resources with energy content used as material*	MJ, LHV	**0**	**0**	**0**	**0**
Non-renewable primary resources used as an energy carrier (fuel)*	MJ, LHV	**387**	**156**	**304**	**847**
Non-renewable primary resources with energy content used as material*	MJ, LHV	**0**	**0**	**0**	**0**
Use of secondary resources					
Secondary materials*	kg	**36.79**	**0**	**0**	**36.79**
Renewable secondary fuels*	MJ, LHV	**0**	**0**	**0**	**0**
Non-renewable secondary fuels*	MJ, LHV	**136**	**0**	**0**	**136**
Abiotic depletion potential					
Abiotic depletion potential for non-fossil mineral resources*	kg Sb eq.	**6.95E-05**	**6.72E-06**	**5.70E-06**	**8.19E-05**
Abiotic depletion potential for fossil resources*	MJ, LHV	**314**	**156**	**304**	**774**
Consumption of freshwater resources					
Consumption of freshwater*	m^3	**1.57**	**0.01**	**0.27**	**1.85**
Waste and output flows					
Hazardous waste disposed*	kg	**0**	**0**	**0**	**0**
Non-hazardous waste disposed*	kg	**3.61**	**0**	**1.05**	**4.65**
High-level radioactive waste, conditioned, to final repository, HLRW*	kg	**x**[1)]	**x**[1)]	**x**[1)]	**x**[1)]
Intermediate and low-level radioactive waste, conditioned, to final repository, ILLRW*	kg	**x**[1)]	**x**[1)]	**x**[1)]	**x**[1)]
Components for reuse*	kg	**1.60**	**0**	**0**	**1.60**
Materials for recycling*	kg	**0.50**	**0**	**27.89**	**28.39**
Materials for energy recovery*	kg	**0**	**0**	**0**	**0**
Recovered energy exported from the product system*	MJ per energy carrier	**0**	**0**	**0**	**0**
Additional inventory parameters for transparency					
Emissions from calcination and removals from carbonation*	kg CO_2 eq.	**56.67**	**0**	**0**	**56.67**
Emissions from combustion of waste from non-renewable sources*	kg CO_2 eq.	**11.64**	**0**	**0**	**11.64**

Table Notes:

x[1)] – The GCCA EPD Tool does not support these indicators.
* Use caution when interpreting results for these categories

LCA Interpretation

The Extraction and Upstream Production (A1) Module is the main contributor to the potential environmental impacts. The potential environmental impacts associated with Module A1 are predominantly driven by the production of cement and reinforcing steel.

The Manufacturing (A3) Module is the second largest contributor, primarily due to the use of propane and heating oil to cure and heat the plant's facilities.

Additional Environmental Information

No additional environmental information is reported.

References

[1] Global Cement and Concrete Association (GCCA) and Portland Cement Association (PCA), GCCA Industry EPD Tool for Cement and Concrete (V4.2), User's Manual, North American version, Prepared by Quantis, December 2023. https://concrete-epd-tool.org/

[2] Global Cement and Concrete Association (GCCA) LCA Database, North American version (V4.2) Prepared by Quantis, December 2023.

[3] NSF PCR for Precast Concrete, V3.0, May 2021

[4] ISO 21930:2017 Sustainability in buildings and civil engineering works - Core rules for environmental product declarations of construction products and services.

[5] ISO 14020:2000 Environmental labels and declarations — General principles

[6] ISO 14040:2006 Environmental management - Life cycle assessment - Principles and framework.

[7] ISO 14044:2006 Environmental management - Life cycle assessment - Requirements and guidelines.

[8] ISO 14025:2006 Environmental labeling and declarations - Type III environmental declarations - Principles and procedures.

[9] ASTM General Program Instructions. V.8.0, April 29, 2020.

[10] Ash Grove, a CRH Company Environmental Product Declaration – Mississauga, Ontario Cement Plant, ASTM International, June 6, 2023. https://pcr-epd.s3.us-east-2.amazonaws.com/753.AshGroveMississaugaCementEPD.pdf

[11] Salit Steel Environmental Product Declaration – Fabricated Steel Reinforcing Bar, SCS Global Services, July 11, 2018. https://www.salitsteel.com/wp-content/uploads/2018/07/SCS-EPD-05041_Salit-Steel_Rebar_071118.pdf

[12] ACLCA 2019, Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017. The American Centre for Life Cycle Assessment. May, 2019. https://aclca.org/aclca-iso-21930-guidance/ https://aclca.org/wp-content/uploads/ISO-21930-Final.pdf

[13] U.S. Environmental Protection Agency (2012). Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) TRACI version 2.1. https://nepis.epa.gov/Adobe/PDF/P100HN53.pdf

[14] Canadian Precast/Prestressed Concrete Institute Environmental Product Declaration – A Regionalized Industry Average EPD for Below Grade Precast Concrete, ASTM International, March 31, 2023. https://pcr-epd.s3.us-east-2.amazonaws.com/913.CPCI_Below%20_Grade_Precast_Concrete.pdf

[15] Cement Association of Canada Environmental Product Declaration – General Use (GU) and Portland-Limestone (GUL) Cements, ASTM International, April 21, 2023. https://pcr-epd.s3.us-east-2.amazonaws.com/919.CAC_General_Use_(GU)_and_Portland-Limestone_(GUL)_Cements.pdf