Raw Material/ Energy Extraction | Preliminary Production | Manufacture of End Products

Environmental Product Declaration (EPD) for Precast Concrete

CPCI
NPCA
PCI

Architectural & Insulated Wall Panel Industry Wide EPD

ASTM INTERNATIONAL

Environmental Product Declaration

According to ISO 14025 and ISO 21930

This EPD is an industry wide or industry average cradle-to-gate EPD for Architectural and Insulated Precast Panels manufactured by Canadian Precast/Prestressed Concrete Institute, National Precast Concrete Association & Precast/Prestressed Concrete Institute members.

EPD PRODUCTION STAGE SUMMARY RESULTS - ONE METRIC TONNE OF ARCHITECTURAL PRECAST PANEL

Category Indicator	Unit	Raw Material Supply A1	Transport A2	Manufacturing A3	Total
Global warming potential	kg CO_2 eq.	265.2	12.7	29.8	307.7
Acidification potential	kg SO_2 eq.	5.6	0.1	0.2	5.8
Eutrophication potential	kg N eq.	0.3	0.0	0.0	0.3
Smog creation potential	kg O_3 eq.	62.8	3.2	1.6	67.6
Ozone depletion potential	kg CFC-11 eq.	1.6E-03	0.0E+00	5.8E-10	1.6E-03
Primary Energy Consumption					
Total Primary Energy	MJ, HHV	2,091.1	193.1	530.2	2,814.4
Non-renewable (fossil, nuclear)	MJ, HHV	2,056.4	192.8	511.2	2,760.4
Renewable (solar, wind, biomass hydroelectric, & geothermal)	MJ, HHV	34.6	0.3	19.0	53.9
Material resources consumption					
Total Material Resource Consumption	kg	1,057.9	0.0	0.0	1,057.9
Non-renewable materials	kg	1,056.7	0.0	0.0	1,056.7
Renewable materials	kg	1.2	0.0	0.0	1.2
Fresh water	l	1,475.9	0.0	258.5	1,734.4
Waste generated					
Non-hazardous	kg	1.1	0.0	64.2	65.3
Hazardous	kg	0.01	0.0	10.0	10.0

EPD PRODUCTION STAGE SUMMARY RESULTS - ONE METRIC TONNE OF INSULATED PRECAST PANEL

Category Indicator	Unit	Raw Material Supply	Transport	Manufacturing	Total
		A1	A2	A3	
Global warming potential	kg CO_2 eq.	279.0	12.6	29.8	321.4
Acidification potential	kg SO_2 eq.	4.5	0.1	0.2	4.8
Eutrophication potential	kg N eq.	0.2	0.0	0.0	0.3
Smog creation potential	kg O_3 eq.	50.7	2.9	1.6	55.1
Ozone depletion potential	kg CFC-11 eq.	3.8E-03	1.5E-11	5.8E-10	3.8E-03
Primary Energy Consumption					
Total Primary Energy	MJ, HHV	2,116.4	183.7	530.2	2,830.3
Non-renewable (fossil, nuclear)	MJ, HHV	2,086.3	183.4	511.2	2,780.9
Renewable (solar, wind, biomass hydroelectric, & geothermal)	MJ, HHV	30	0.3	19.0	49.3
Material resources consumption					
Total Material Resource Consumption	kg	1,040.7	0.0	0.0	1,040.7
Non-renewable materials	kg	1,039.9	0.0	0.0	1,039.9
Renewable materials	kg	0.8	0.0	0.0	0.8
Fresh water	l	1,312.7	0.0	251.3	1,564.1
Waste generated					
Non-hazardous	kg	1.1	0.0	64.2	65.3
Hazardous	kg	0.01	0.0	10.0	10.0

ASTM International Certified Environmental Product Declaration

This is an industry wide business-to-business Type III environmental product declaration for archtectural precast. This declaration has been prepared in accordance with ISO 14025 and ISO 21930, 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 ofarchtectural precast available in the USA and Canada in accordance with international standards.

Environmental Product Declaration Summary

Owners of the EPD	
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
NPCA Precast ... The Concrete Solution	**National Precast Concrete Association** 1320 City Center Drive, Suite 200 Carmel, IN 46032 Link (URL): www.precast.org
PCI Precast/Prestressed Concrete Institute	**Precast/Prestressed Concrete Institute** 200 West Adams St., Suite 2100 Chicago, IL 60606 Link (URL): www.pci.org Each trade association/institute and their respective member companies provided both LCI and meta-data for the reference year 2014. Their combined membership operate more than 1,000 facilities in the US and Canada producing structural, architectural, utility and specialty precast products used on, above and below grade applications. This EPD background report represents an average product as a production-weighted average from plants of more than one manufacturer. The owner of the declaration is liable for the underlying information and evidence.

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Product Group and Name	Architectural and Insulated Precast Panels (UN CPC 3755)
Product Definition	***Architectural precast panel*** - a single-wythe exterior wall panel and/or architectural trim product. ***Insulated Precast Panel*** - two conventionally reinforced or prestressed concrete wythes with a continuous layer of rigid insulation placed between. Architectural and Insulated Precast Panels are engineered construction products 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.
Product Category Rules	ASTM International, Product Category Rules For Preparing an Environmental Product Declaration For Precast Concrete, March 2015 [1].
Certification Period	11.11.2015 - 11.11.2020
Declared Unit	1 metric tonne (1,000 kg) of either architectural or insulated precast panels and optionally 1 short ton (2,000 lbs) of each product.
ASTM Declaration Number	EPD-016

Program Operator			ASTM International
Declaration Holder			Canadian Precast/Prestressed Concrete Institute, National Precast Concrete Association & Precast/Prestressed Concrete Institute
Product group **Precast Concrete**	**Date of Issue** 09.11. 2015	**Period of Validity** 5 years	**Declaration Number** EPD-016
Declaration Type An industry average "cradle-to-gate" EPD for Architectural and Insulated Precast Panels as singular product groups manufactured by CPCI, NPCA and PCI 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.			
Applicable Countries United States and Canada			

Product Applicability Architectural and Insulated Precast Panel products satisfy a wide array of building and civil engineering applications.	
Content of the Declaration This declaration follows Section 11; Content of the EPD, ASTM International, Product Category Rules For Preparing an Environmental Product Declaration For Precast Concrete, March 2015.	
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 cert@astm.org
EPD Project Report Information	
EPD Project Report	An Industry Average Cradle-to-Gate Life Cycle Assessment of Precast Concrete Products for the US and Canadian Markets, October 2015
Prepared by Member of the 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
PCR Information	
Program Operator	ASTM International
Reference PCR	ASTM International, Product Category Rules For Preparing an Environmental Product Declaration For Precast Concrete, March 2015
PCR review was conducted by:	Nicholas Santero, PE International (Chair) Renee L. Gratton, LEED A.P., Construction Resource Initiatives Council Randy Primeau, CET, LEED AP, Prestressed Systems Inc.

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.

For the purposes of this EPD the following broad descriptive definition for Architectural and Insulated Precast Panels is as follows [1]:

Architectural precast | single-wythe exterior wall panels and architectural trim products. Architectural precast products can be conventionally reinforced or prestressed concrete that will be permanently exposed to view and therefore require more attention in selection of the concrete materials, forming, placing, and finishing to obtain the desired architectural appearance.

Insulated precast panels | two conventionally reinforced or prestressed concrete wythes with a continuous layer of rigid insulation placed between.

This EPD represents a baseline or benchmark for the Canadian and United States Architectural and Insulated Precast Panels industry and exemplifies an average product group as an average from more than one manufacturer.

2 PRODUCT APPLICATION

Architectural and Insulated Precast Panel 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 either Architectural or Insulated Precast Panel. Data is additionally presented per short ton [1].

4 MATERIAL CONTENT

Table 1 below presents the weighted average material content by input material for the architectural precast panel product group as derived from participating member facilities LCI data for the timeline 2014. Table 2 provides similar information for the insulated precast panel product group.

Table 1: Weighted Average Material Content for Architectural Precast Panel Product Group

Material Inputs	SI Units per Metric tonne of Architectural Precast		Imperial Units per Short ton of Architectural Precast	
	Amount	Unit	Amount	Unit
Portland Cement	143.5	kg	286.9	lbs
Portland Limestone Cement (PLC)	13.9	kg	27.7	lbs
Fine Aggregate - natural sand	302.7	kg	605.4	lbs
Fine Aggregate - manufactured	40.6	kg	81.2	lbs
Coarse Aggregate - natural gravel	185.5	kg	371.0	lbs
Coarse Aggregate - crushed	209.6	kg	419.2	lbs
Manufactured Lightweight Aggregate	1.2	kg	2.4	lbs
Natural Lightweight Aggregate	0.1	kg	0.1	lbs
SCMs - Fly Ash	6.0	kg	12.1	lbs
Chemical Admixture (CA) - Air Entraining	0.18	litre	0.04	gallon
CA - Water Reducer/Plasticizer	0.25	litre	0.06	gallon
CA - Accelerator	0.22	litre	0.05	gallon
CA - High Range Water Reducer (HRWR)/Super Plasticizer and/or Viscosity Modifying Admixture (VMA)	0.89	litre	0.21	gallon
CA - Corrosion Inhibiting	0.07	litre	0.02	gallon
CA - Retarding Admixture	0.03	litre	0.01	gallon
Form Release Agent	0.27	litre	0.07	gallon
Rebar	17.9	kg	35.8	lbs
Welded Wire Reinforcement (WWR)	9.0	kg	18.0	lbs
Steel Anchors	7.9	kg	15.9	lbs
Steel Stressing Strand	8.9	kg	17.8	lbs
Steel Fibers	0.04	kg	0.09	lbs
Extruded Polystyrene	0.72	bd ft	0.66	bd ft
Brick	3.97	kg	7.95	lbs
Natural Stone	0.83	kg	1.66	lbs
Pigments	1.62	kg	3.23	lbs
Net Consumables	0.08	litre	0.02	gallon
Total Batch Water Use	57.9	litre	13.9	gallon

Table 2: Weighted Average Material Content for Insulated Precast Panel Product Group

Material Inputs	SI Units per Metric tonne of Insulated Precast		Imperial Units per Short ton of Insulated Precast	
	Amount	Unit	Amount	Unit
Portland Cement	160.9	kg	321.9	lbs
Portland Limestone Cement (PLC)	3.9	kg	7.8	lbs
Fine Aggregate - natural sand	278.2	kg	556.5	lbs
Fine Aggregate - manufactured	58.6	kg	117.1	lbs
Coarse Aggregate - natural gravel	121.3	kg	242.6	lbs
Coarse Aggregate - crushed	258.3	kg	516.6	lbs
Manufactured Lightweight Aggregate	1.0	kg	2.0	lbs
Natural Lightweight Aggregate	4.3	kg	8.6	lbs
SCMs - Fly Ash	6.7	kg	13.3	lbs
SCMs - Slag Cement	0.03	kg	0.1	lbs
Chemical Admixture (CA) - Air Entraining	0.14	litre	0.03	gallon
CA - Water Reducer/Plasticizer	0.20	litre	0.05	gallon
CA - Accelerator	0.38	litre	0.09	gallon
CA - High Range Water Reducer (HRWR)/ Super Plasticizer and/or Viscosity Modifying Admixture (VMA)	0.66	litre	0.16	gallon
CA - Corrosion Inhibiting	0.09	litre	0.02	gallon
CA - Retarding Admixture	0.07	litre	0.02	gallon
Form Release Agent	0.10	litre	0.02	gallon
Rebar	11.4	kg	22.7	lbs
Welded Wire Reinforcement (WWR)	8.0	kg	15.9	lbs
Steel Anchors	5.2	kg	10.5	lbs
Steel Stressing Strand	12.5	kg	24.9	lbs
Carbon Fibre Reinforced Polymer Strand	0.06	kg	0.12	lbs
Glass Fibre Reinforced Polymer (GFRP) reinforcing bars	0.004	kg	0.009	lbs
Expanded Polystyrene	11.95	bd ft	10.85	bd ft
Extruded Polystyrene	20.62	bd ft	18.70	bd ft
Brick	2.60	kg	5.19	lbs
Pigments	0.72	kg	1.45	lbs
Net Consumables	0.10	litre	0.02	gallon
Total Batch Water Use	65.1	litre	15.6	gallon

5 PRODUCT STAGE

The product stage includes the following modules [1]:
A1 Raw material supply;
A2 Transport to the manufacturer; and
A3 Manufacturing and terminal operations.

Figure 2 shows the product stage system boundary for the declared product system.

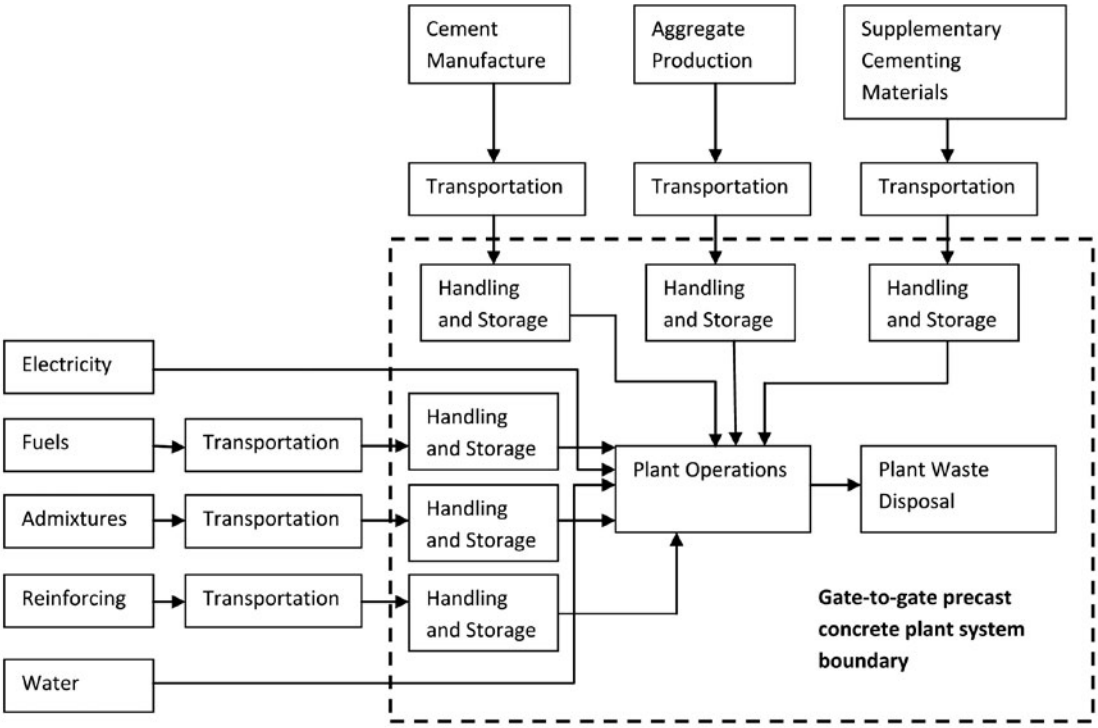

Figure 1 Product stage system boundary

The Product Stage includes the following processes [1]:

- 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);
- Final disposition of pre-consumer wastes inclusive of transportation;

The Product Stage excludes the following processes [1]:

- 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

CPCI, NPCA and PCI members combined operate about 1000 precast manufacturing facilities in the United States and Canada. Manufacturing facilities vary in size as well as the product types they produce. For example, some firms only produce structural or underground products while others may produce all four of the product types of interest as well as other specialty products. Life cycle inventory data were collected from 99 facilities within Canada and the United States for the 2014 reference year – representing slightly less than 10% of all members. In total the participating facilities produced in the order of 5.5 million metric tonnes of precast. Appendix A lists the plants that provided both meta and life cycle inventory data to support this EPD.

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 group, but provided annual product group production figures. Each plant also provided averaged formulation data for each product group they produce and this data was also averaged on a production weighted basis, but only across plants producing the precast product of interest; in this case architectural and insulated precast. As this EPD represents an industry benchmark, the commissioners agreed it would be more informative to also report a median result for input and output flows under direct control of precast producers; i.e., core manufacturing (A3). The median flows for electricity and fuels, non-batch water use as well as generated wastes were determined and modeled (linked to A1 and A2 upstream modules). The “median” production result is reported separately and provides an alternative benchmark for precast producers.

6.2 CUT OFF RULES, ALLOCATION RULES AND DATA QUALITY REQUIREMENTS

Cut-off rules, as specified in ASTM PCR for precast concrete: 2015, section 7.3, were applied [1]. 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.

Allocation procedures observed the requirements and guidance of ISO 14044:2006, clause 4.3 and those specified in ASTM PCR for precast concrete, section 7.5. The majority of the precast facility operations were dedicated to the production of one or more of the four 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 (Section 7.5, ASTM PCR for precast concrete):

- Allocation related to transport is based on the mass and distance of transported input;
- Recovered materials (slag cement, fly ash, synthetic gypsum, etc.) are considered raw materials. Only the materials, water, energy, emissions, and other elemental flows associated with reprocessing, handling, sorting, and transportation from the point of the generating industrial process to their use in the production process are considered. 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 ASTM's Precast Concrete PCR: 2015, section 7.3, were observed [1]. 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 and United States 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 as well as precast product sub groups of interest. The relevant background materials and processes were taken from the US LCI Database (adjusted for known data placeholders known as "dummy"[1]), ecoinvent v 3.1 LCI database for United States and Canada and modeled in SimaPro software v.8.0.4, March 2015.

[1] "Dummy" is a term used by US LCI database that refers to "empty" LCI data sets (technosphere processes).

Consistency: To ensure consistency, the LCI modeling of the production weighted input and output LCI data for each precast product sub-groups 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 N.A. Precast Athena LCI database developed in SimaPro, 2015. A high level of transparency is provided throughout the report 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 summarized in Table 2. 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: 2014 (12 months).
- ***Generic data:*** the most appropriate LCI datasets were used as found in the US LCI (adjusted) Database, ecoinvent v.3.1 database for United States, Canada and global, 2014.
- ***Geographical coverage:*** the geographical coverage is the United States and Canada.
- ***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 results are calculated on the basis of one metric tonne (1,000 kg) of architectural precast (Table 3) and insulated precast panels (Table 6), but are also provided for one short ton (2000 lbs.) of architectural precast (Table 4) and insulated precast panels (Table 7). The weighted average production results are delineated by information module (A1 – Raw material supply), (A2 – Raw material transport), and (A3 – precast core manufacturing). The "A3 Median Total" is the Production total (A1, A2 and A3 summed) based on the calculated median flows for A3.

Tables 5 and 8 provide a percent contribution summary by information model for each of the supported indicators and inventory parameters for architectural and insulated precast panels, respectively. Contribution analysis is an analytical method used to support the interpretation of LCA results and to facilitate the reader's understanding of the environmental profile of the declared product.

As per ASTM PCR for precast concrete: 2015, Section 8, 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.

Table 3: LCA results – Architectural Precast Panel, one metric tonne - absolute basis

Category Indicator	Unit	Raw Material Supply	Transport	Manufacturing	Weighted Average Total	A3 Median Total
		A1	A2	A3		
Global warming potential	kg CO_2 eq.	265.2	12.7	29.8	307.7	303.5
Acidification potential	kg SO_2 eq.	5.6	0.1	0.2	5.8	5.8
Eutrophication potential	kg N eq.	0.3	0.0	0.0	0.3	0.3
Smog creation potential	kg O_3 eq.	62.8	3.2	1.6	67.6	67.5
Ozone depletion potential	kg CFC-11 eq.	1.6E-03	0.0E+00	5.8E-10	1.6E-03	1.6E-03
Primary Energy Consumption						
Total Primary Energy	MJ, HHV	2,091.1	193.1	530.2	2,814.4	2,542.2
Non-renewable (fossil, nuclear)	MJ, HHV	2,056.4	192.8	511.2	2,760.4	2,688.4
Renewable (solar, wind, biomass hydroelectric, & geothermal)	MJ, HHV	34.6	0.3	19.0	53.9	88.2
Material resources consumption						
Total Material Resource Consumption	kg	1,057.9	0.0	0.0	1,057.9	1,057.9
Non-renewable materials	kg	1,056.7	0.0	0.0	1,056.7	1,056.7
Renewable materials	kg	1.2	0.0	0.0	1.2	1.2
Fresh water	L	1,475.9	0.0	258.5	1,734.4	1,577.6
Waste generated						
Non-hazardous	kg	1.1	0.0	64.2	65.3	1,057.9
Hazardous	kg	0.01	0.0	10.0	10.0	1,056.7

Note: A3 Median Total is the Production total (A1, A2 and A3 summed) based on the calculated median flows for A3

Table 4: LCA results- Architectural Precast Panel, one short tonne - absolute basis

Category Indicator	Unit	Raw Material Supply	Transport	Manufacturing	Weighted Average Total	A3 Median Total
		A1	A2	A3		
Global warming potential	kg CO_2 eq.	240.6	11.5	27.0	279.1	275.3
Acidification potential	kg SO_2 eq.	5.0	0.1	0.2	5.3	5.3
Eutrophication potential	kg N eq.	0.3	0.0	0.0	0.3	0.3
Smog creation potential	kg O_3 eq.	57.0	2.9	1.4	61.3	61.2
Ozone depletion potential	kg CFC-11 eq.	1.4E-03	0.0E+00	5.3E-10	1.4E-03	1.4E-03
Primary Energy Consumption						
Total Primary Energy	MJ, HHV	1,897.0	175.2	481.0	2,553.2	2,306.2
Non-renewable (fossil, nuclear)	MJ, HHV	1,865.5	174.9	463.7	2,504.2	2,438.8
Renewable (solar, wind, biomass hydroelectric, & geothermal)	MJ, HHV	31.4	0.3	17.3	48.9	80.0
Material resources consumption						
Total Material Resource Consumption	kg	959.7	0.0	0.0	959.7	959.7
Non-renewable materials	kg	958.6	0.0	0.0	958.6	958.6
Renewable materials	kg	1.1	0.0	0.0	1.1	1.1
Fresh water	L	1,338.9	0.0	234.5	1,573.4	1,431.2
Waste generated						
Non-hazardous	kg	1.0	0.0	58.3	59.2	11.4
Hazardous	kg	0.005	0.0	9.0	9.1	0.2

Note: A3 Median Total is the Production total (A1, A2 and A3 summed) based on the calculated median flows for A3

Table 5: LCA results- Architectural Precast Panels - percent basis

Weighted Average Basis	Raw Material Supply	Transport	Manufacturing
	A1	A2	A3
Global warming potential	86.2%	4.1%	9.7%
Acidification potential	95.4%	1.3%	3.3%
Eutrophication potential	97.0%	1.9%	1.1%
Smog creation potential	92.9%	4.8%	2.3%
Ozone depletion potential	100.0%	0.0%	0.0%
Total Primary Energy	74.3%	6.9%	18.8%
Non-renewable (fossil, nuclear)	74.5%	7.0%	18.5%
Renewable (solar, wind, biomass hydroelectric, & geothermal)	64.2%	0.5%	35.3%
Total Material Resource Consumption	100.0%	0.0%	0.0%
Non-renewable materials	100.0%	0.0%	0.0%
Renewable materials	100.0%	0.0%	0.0%
Fresh water	85.1%	0.0%	14.9%
Non-hazardous	1.6%	0.0%	98.4%
Hazardous	0.1%	0.0%	99.9%

Table 6: LCA results – Insulated Precast Panels, one metric tonne - absolute basis

Category Indicator	Unit	Raw Material Supply	Transport	Manufacturing	Weighted Average Total	A3 Median Total
		A1	A2	A3		
Global warming potential	kg CO_2 eq.	279.0	12.6	29.8	321.4	317.2
Acidification potential	kg SO_2 eq.	4.5	0.1	0.2	4.8	4.7
Eutrophication potential	kg N eq.	0.2	0.0	0.0	0.3	0.3
Smog creation potential	kg O_3 eq.	50.7	2.9	1.6	55.1	55.0
Ozone depletion potential	kg CFC-11 eq.	3.8E-03	1.5E-11	5.8E-10	3.8E-03	3.8E-03
Primary Energy Consumption						
Total Primary Energy	MJ, HHV	2,116.4	183.7	530.2	2,830.3	317.2
Non-renewable (fossil, nuclear)	MJ, HHV	2,086.3	183.4	511.2	2,780.9	4.7
Renewable (solar, wind, biomass hydroelectric, & geothermal)	MJ, HHV	30.0	0.3	19.0	49.3	0.3

Category Indicator	Unit	Raw Material Supply	Transport	Manufacturing	Weighted Average Total	A3 Median Total
		A1	A2	A3		
Material resources consumption						
Total Material Resource Consumption	kg	1,040.7	0.0	0.0	1,040.7	1,040.7
Non-renewable materials	kg	1,039.9	0.0	0.0	1,039.9	1,039.9
Renewable materials	kg	0.8	0.0	0.0	0.8	0.8
Fresh water	L	1,312.7	0.0	251.3	1,564.1	1,407.4
Waste generated						
Non-hazardous	kg	1.1	0.0	64.2	65.3	12.6
Hazardous	kg	0.01	0.0	10.0	10.0	0.2

Note: A3 Median Total is the Production total (A1, A2 and A3 summed) based on the calculated median flows for A3

Table 7: LCA results- Insulated Precast Panel, one short tonne - absolute basis

Category Indicator	Unit	Raw Material Supply	Transport	Manufacturing	Weighted Average Total	A3 Median Total
		A1	A2	A3		
Global warming potential	kg CO_2 eq.	253.1	11.5	27.0	291.6	287.8
Acidification potential	kg SO_2 eq.	4.1	0.1	0.2	4.3	4.3
Eutrophication potential	kg N eq.	0.2	0.0	0.0	0.2	0.2
Smog creation potential	kg O_3 eq.	46.0	2.6	1.4	50.0	49.9
Ozone depletion potential	kg CFC-11 eq.	3.5E-03	1.3E-11	5.3E-10	3.5E-03	3.5E-03
Primary Energy Consumption						
Total Primary Energy	MJ, HHV	1,920.0	166.6	481.0	2,567.6	2,320.6
Non-renewable (fossil, nuclear)	MJ, HHV	1,892.7	166.4	463.7	2,522.8	2,457.5
Renewable (solar, wind, biomass hydroelectric, & geothermal)	MJ, HHV	27.3	0.2	17.3	44.8	75.9
Material resources consumption						
Total Material Resource Consumption	kg	944.1	0.0	0.0	944.1	944.1
Non-renewable materials	kg	943.4	0.0	0.0	943.4	943.4
Renewable materials	kg	0.7	0.0	0.0	0.7	0.7
Fresh water	L	1,190.9	0.0	228.0	1,418.9	1,276.7
Waste generated						
Non-hazardous	kg	1.0	0.0	58.3	59.2	11.4
Hazardous	kg	0.005	0.0	9.0	9.1	0.2

Note: A3 Median Total is the Production total (A1, A2 and A3 summed) based on the calculated median flows for A3

Table 8: LCA results- Insulated Precast Panels - percent basis

Weighted Average Basis	Raw Material Supply	Transport	Manufacturing
	A1	A2	A3
Global warming potential	86.8%	3.9%	9.3%
Acidification potential	94.3%	1.6%	4.1%
Eutrophication potential	96.3%	2.2%	1.5%
Smog creation potential	92.0%	5.2%	2.8%
Ozone depletion potential	100.0%	0.0%	0.0%
Total Primary Energy	74.8%	6.5%	18.7%
Non-renewable (fossil, nuclear)	75.0%	6.6%	18.4%
Renewable (solar, wind, biomass hydroelectric, & geothermal)	60.9%	0.5%	38.6%
Total Material Resource Consumption	100.0%	0.0%	0.0%
Non-renewable materials	100.0%	0.0%	0.0%
Renewable materials	100.0%	0.0%	0.0%
Fresh water	83.9%	0.0%	16.1%
Non-hazardous	1.6%	0.0%	98.4%
Hazardous	0.1%	0.0%	99.9%

7.2 INTERPRETATION

Across the three production information modules for both architectural and insulated precast panels, module A1- raw material supply contributes the largest share of the impact category results – accounting for 100% (ozone depletion) and about 86% (global warming potential) of the impact burden. The upstream raw material supply (A1) also accounts for the largest 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 precast products – generally 5% or less. Manufacturing (A3) architectural and insulated precast panel products contributes in the order of 10% of all greenhouse gases and 20% of the primary energy use.

The life cycle impact indicator results, based on median A3 manufacturing flows, vary little as these indicators are driven primarily by the specified upstream materials (A1) for each precast product group. Generally, the median result indicators and metrics are lower than those of the weighted average profile, indicating that the median plant uses less energy and water and generates less solid wastes.

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, NPCA and PCI member manufacturing facilities follow the ISO 14001 environmental management system, ISO 9001 quality management system or other in-house quality control systems.

Health Protection

The OSHA standards are applicable and followed.

- U.S. Department of Labor, Occupational Safety & Health Administration (OSHA),

29 CFR, PART 1910 Occupational Safety and Health Standards.

(https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=1&p_keyvalue=1910)

No additional health protection measures extending beyond mandatory occupational safety measures for commercial operations are required.

9 DECLARATION TYPE AND PRODUCT AVERAGE DECLARATION

The type of EPD is defined as:

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

This EPD for architectural and insulated precast concrete wall panels, UN CPC 3755 is an average product EPD, as an average from several CPCI, NPCA and PCI member facilities.

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 ASTM's Precast Concrete PCR: 2015:

- EPDs from different programs (using different PCR) may not be comparable.
- Declarations based on the ASTM Precast Concrete PCR [1] 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. ASTM International, Product Category Rules For Preparing an Environmental Product Declaration For Precast Concrete, March 2015.
2. ISO 21930: 2007 Building construction – Sustainability in building construction – Environmental declaration of building products.
3. ISO 14025: 2006 Environmental labeling and declarations - Type III environmental declarations - Principles and procedures.
4. ISO 14044: 2006 Environmental management - Life cycle assessment - Requirements and guidelines.
5. ISO 14040: 2006 Environmental management - Life cycle assessment - Principles and framework.
6. ASTM Program Operator for Product Category Rules (PCRs) and Environmental Product Declarations (EPDs), General Program Instructions, October 2012.

Appendix A – Participating Plant List

Armtec, Richmond, BC	Gate Precast Company (Kissimmee), Kissimmee, FL
Arrow Concrete Products, Granby, CT	Gate Precast Company (Monroeville), Monroeville, AL
Arto Brick & Tile, Gardena, CA	Gate Precast Company (Oxford), Oxford, NC
Atlanta Structural Concrete Company, Buchanan, GA	Gate Precast Company (Pearland), Pearland, TX
Bartow Precast, Cartersville, GA	Gate Precast Company (Winchester), Winchester, KY
BC Concrete, Inc. dba Missoula Concrete Construction, Missoula, MT	Geneva Pipe & Precast, Orem, UT
Béton Préfabriques Du Lac Inc., Alma, QC	GPRM Prestress, Kapolei, HI
Béton Préfabriques Du Richelieu, Saint-Jean-sur-Richelieu, QC	Granite Precast, Bellingham, WA
Blakeslee Prestress, Inc., Branford, CT	Hanson Structural Precast Eagle (HBP - Caldwell), Caldwell, ID
By Crete, Lebanon, PA	Heldenfels Enterprises, Inc., Corpus Christi, TX
Camp Precast Concrete Products, Milton, VT	Heldenfels Enterprises, Inc., San Marcos, TX
Cement Industries, Inc., Fort Myers, FL	High Concrete Group LLC - Denver Plant, Denver, PA
Champion Precast, O'Fallon, MO	High Concrete Group LLC - Springboro Plant, Springboro, OH
Clark Pacific - Fontana Plant, Fontana, CA	Kerkstra Precast, Inc., Grandville, MI
Clark Pacific - Woodland Plant, Woodland, CA	Kie-Con, Inc., Antioch, CA
Colorado Precast Concrete, Loveland, CO	Kistner Concrete Products, Batavia, NY
Columbia Precast Products, Washougal, WA	Lafarge Precast, Calgary/Edmonton, AB
Con Cast Pipe Inc., Guelph, ON	Lafarge Precast, Winnipeg, MB
Concrete Industries, Inc., Lincoln, NE	Lee's Precast Concrete, Aberdeen, MS
Concrete Technology Corporation, Tacoma, WA	Leesburg Concrete Company, Leesburg, FL
Conewago Precast Building Systems, Hanover, PA	Lindsey Precast, Franklinton, NC
Construction Products, Inc., Jackson, TN	Lindsey Precast, Colorado Springs, CO
Coreslab Structures (Ariz) Inc., Phoenix, AZ	Lockwood Bros. Concrete Products, Armstrong, BC
East Texas Precast Co., LTD., Hempstead, TX	Lowe Precast Inc., Waco, TX
EnCon Colorado, Denver, CO	Manco Structures, TD., Schertz, TX
Fabcon Precast, Barnesville, PA	Metromont - Greenville, Greenville, SC
Fabcon Precast, Grove City, OH	Metromont Corp. - Bartow, Bartow, FL
Fabcon Precast, Savage, MN	Metromont Corp. - Charlotte, Charlotte, NC
Florence Concrete Products, Inc., Sumter, SC	Metromont Corp. - Hiram, Hiram, GA
Gage Brothers, Sioux Falls, SD	Metromont Corp. - Richmond, Richmond, VA
Gate Precast Company (Ashland City), Ashland City, TN	Mid South Prestress LLC, Pleasant View, TN
Gate Precast Company (Hillsboro), Hillsboro, TX	Molin Concrete Products Company, Lino Lakes, MN
Gate Precast Company (Jacksonville), Jacksonville, FL	North American Precast Company LLC. (NAPCO), San Antonio, TX

Appendix A – Participating Plant List

Oldcastle - Avon, Avon, CT	Strescon Limited, Bedford, NS
Oldcastle - Rehoboth, Rehoboth, MA	Strescon Limited, Saint John, NB
Oldcastle Precast Building Systems, Edgewood, MD	Stresscon Corporation, Colorado Springs, CO
Oldcastle Precast Building Systems, Selkirk, NY	Surespan Structures Ltd., Duncan, BC
Oldcastle Precast Inc., Perris, CA	Tekna Corporation, Charleston, SC
Oldcastle Precast, Fontana, CA	Tindall Corporation - Georgia Division, Conley, GA
Oldcastle Precast, San Diego, CA	Tindall Corporation - Texas Division, San Antonio, TX
Pennstress, a division of MacInnis Group, Inc., Roaring Spring, PA	Tindall Corporation Virginia Division, Petersburg, VA
Prestressed Casting Co. - Ozark Plant, Ozark, MO	Tindall Corporation, Spartanburg, SC
Prestressed Casting Co. - Springfield Plant, Springfield, MO	Unistress Corp, Pittsfield, MA
Rocky Mountain Prestress ARCHITECTURAL Plant, Denver, CO	Walters & Wolf Precast, Fremont, CA
Rocky Mountain Prestress STRUCTURAL Plant, Denver, CO	Wells Concrete - Albany Plant, Albany, MN
Schokbeton Québec Inc., St-Eustache, QC	Wells Concrete - Grandforks, Grandforks, ND
Shea Concrete Products, Wilmington, MA	Wells Concrete - Wells, Wells, MN
SI Precast Concrete, Grandview, MO	Wilbert Precast, Spokane, WA
Spancrete Southeast, Inc., Sebring, FL	William E. Dailey Precast, LLC, Shaftsbury, VT
Spancrete, Valders, WI	

The Canadian Precast/Prestressed Concrete Institute (CPCI), the National Precast Concrete Association (NPCA) and the Precast/Prestressed Concrete Institute (PCI) are the leading technical resources (Body of Knowledge (BOK)) for the precast concrete industry in North America. From this BOK building codes, design guides, educational programs, certification, sustainability programs, and new research ideas are derived.

This joint industry initiative develops, maintains, and disseminates the BOK necessary for designing, fabricating, and constructing sustainable and resilient precast concrete structures.

Canadian Precast/Prestressed Concrete Institute **www.cpci.ca**

National Precast Concrete Association **www.precast.org**

Precast/Prestressed Concrete Institute **www.pci.org**