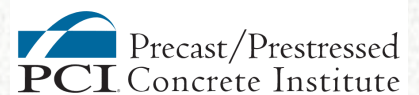




According to ISO 14025:2006 and ISO 21930:2017

Environmental Product Declaration for Glass- Fiber-Reinforced Concrete



ASTM INTERNATIONAL

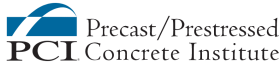
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ASTM International Certified Environmental Product Declaration

This is a business-to-business Type III environmental product declaration for glass-fiber-reinforced concrete (GFRC) as produced by Precast/Prestressed Concrete Institute (PCI) members. This declaration has been prepared in accordance with ISO 14025:2006 and ISO 21930:2017, the governing precast concrete product category rules (PCR) and ASTM international's EPD program rules.

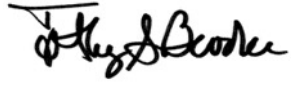

The intent of this document is to further the development of more sustainable construction products by providing comprehensive environmental information related to potential impacts of GFRC in accordance with international standards.

Environmental Product Declaration Summary

EPD Owner	
	Precast/Prestressed Concrete Institute 8770 W Bryn Mawr Ave Suite 1150, Chicago, IL 60631, United States www.pci.org
Product Group and Name	Glass-Fiber-Reinforced Concrete (UN CPC 3755)
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.
Product Category Rules	NSF PCR for Precast Concrete, V3.0, May 2021. [5].
Certification Period	03.05.2023 - 03.05.2028
Declared Unit	1 metric tonne (1,000 kg) of glass-fiber-reinforced concrete
ASTM Declaration Number	EPD # 440



Environmental Product Declaration for Glass-Fiber-Reinforced Concrete

EPD Program Operator	ASTM International
Declaration Holder	Precast/Prestressed Concrete Institute
Declaration Type <p>A “cradle-to-gate” EPD for glass-fiber-reinforced concrete as a product group manufactured by 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.</p>	
Product Applicability <p>Glass-fiber-reinforced concrete products satisfy a wide array of applications</p>	
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: <div style="display: flex; justify-content: space-around;"> Internal External </div> <div style="text-align: center;"> X </div>	<p>Timothy Brooke</p> <p>ASTM International 100 Barr Harbor Dr. West Conshohocken, PA 19428</p> <p>tbrooke@astm.org</p> 
EPD Project Report Information	
EPD Project Report	A Cradle-to-Gate LCA of Glass-Fiber-Reinforced Concrete Products Produced by PCI Members, January 2023
Prepared by  Athena Sustainable Materials Institute	<p>Athena Sustainable Materials Institute 119 Ross Avenue, Suite 100 Ottawa, Ontario, Canada K1Y 0N6</p> <p>info@athenasmi.org</p>
This EPD project report was independently verified by in accordance with ISO 14025 and the reference PCR:	<p>Thomas P. Gloria, Ph. D. Industrial Ecology Consultants 35 Bracebridge Rd. Newton, MA 02459-1728</p> <p>t.gloria@industrial-ecology.com</p>
This EPD was prepared using WAP Sustainability's 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:	<p>Dr. Thomas Gloria, Industrial Ecology Consultants Mr. Bill Stough, Bill Stough, LCC Dr. Michael Overcash, Environmental Clarity</p>



1 PRODUCT IDENTIFICATION

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. Glass-fiber-reinforced concrete, or GFRC, is a type of precast concrete that utilizes alkali-resistant glass fibers as reinforcement.

2 PRODUCT APPLICATION

GFRC products are engineered products satisfying a wide array of applications.

3 DECLARED UNIT

The declared unit is 1 metric tonne of GFRC.

4 MATERIAL CONTENT

Table 1 below presents the material content by input material for the GFRC product as derived from LCI data for 12 consecutive months beginning April 1, 2021, and concluding March 31, 2022.

Table 1: Material Content for Glass-Fiber-Reinforced Concrete Product Group

Ingredients	Unit	Amount per ton
Cement		
Portland Cement	lb	588.9
Aggregate		
Crushed Coarse Aggregate	lb	5.97
Crushed Fine Aggregate	lb	59.8
Natural Fine Aggregate	lb	624.2
Other Materials		
Reinforcing bar	lb	13.8
Steel Anchors	lb	68.0
Glass Fiber	lb	34.0
Light Gauge Steel	lb	374.8
Structural steel	lb	127.9
Thin Brick	lb	46.0
Pigments	lb	6.0
Admixtures/form release agents	gal.	10.5
Batch water	gal.	52.4



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

All gate-to-gate LCI flow data for energy, total water use, emissions and waste generated were used to determine an overall per unit precast plant operations profile. These per-unit gate-to-gate operational flows were used to calculate the plant production effects for GFRC. These data were also averaged on a production weighted basis, but only across plants producing the precast product of interest.

6.2 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.

In addition, the following allocation rules were 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 blast 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 participating member companies through measurement and calculation collected primary data on their production of GFRC. 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 GFRC. The relevant background materials and processes were taken from the US LCI Database, ecoinvent v 3.4 LCI database for United States and/or global and modeled in WAP Sustainability Consulting's Concrete LCA Software v2 (February 2022).

Consistency: To ensure consistency, the LCI modeling of the production input and output LCI data for all precast products used the same modeling structure 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 Precast LCI database developed in WAP's 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: April 1, 2021, through March 31, 2022 (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.
- **Geographical coverage:** the geographical coverage is United States.
- **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 based on one metric tonne (1,000 kg) of GFRC (Table 2). The GFRC production results are delineated by information module (A1 – Raw material supply), (A2 – Raw material transport), and (A3 – precast core manufacturing).

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 – Glass-Fiber-Reinforced Concrete, one metric ton

Impact category and inventory indicators	Unit	Module A1	Module A2	Module A3	Total (A1-A3)
Environmental impact Indicators					
Global warming potential (GWP)	kg CO ₂ eq.	907.56	78.26	126.54	1112.36
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 eq.	8.06E-06	3.24E-09	6.04E-06	1.41E-05
Eutrophication potential (EP)	kg N eq.	1.13	0.06	0.57	1.76
Acidification potential of soil and water sources (AP)	kg SO ₂ eq.	16.08	1.02	0.43	17.53
Formation potential of tropospheric ozone (POCP)	kg O ₃ eq.	30.75	27.25	6.75	64.74
Use of primary resources					
Renewable primary energy resources as energy (fuel), (RPRE)*	MJ, NCV	730.07	0.00	226.10	956.17
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	9655.08	1167.75	1931.70	12754.53
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	8645.34	1101.57	1631.42	11378.33
Abiotic depletion potential for non-fossil mineral resources (ADPelements)*	kg Sb	0.01	0.00	0.00	0.01
Consumption of freshwater resources					
Consumption of fresh water	m ³	2.92	0.00	4.20	7.12
Waste and output flows					
Hazardous waste disposed*	kg	0.01	0.00	0.09	0.10
Non-hazardous waste disposed*	kg	114.07	0.00	80.37	194.44
High-level radioactive waste*	m ³	4.65E-02	0.00E+00	8.84E-08	4.65E-02
Intermediate and low-level radioactive waste*	m ³	1.61E-04	0.00E+00	8.49E-07	1.62E-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 CO ₂ eq.	123.71	0.00	0.00	123.71

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 GFRC products – generally 10% or less. Manufacturing (A3) GFRC products contributes in the order of 10% of all greenhouse gases and about 15-20% of the primary energy use.

8 ADDITIONAL ENVIRONMENTAL INFORMATION

Quality and Environmental Management Systems

In general, PCI-member manufacturing facilities follow ANSI/PCI 128-2019, *Specification for Glass-Fiber-Reinforced Concrete Panels*; 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 GFRC products covering the product stage (modules A1 to A3) and is intended for use in Business-to-Business communication.

This EPD for GFRC, UN CPC 3755, is a specific product EPD.

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 ISO 21930:2017
<https://aclca.org/aclca-iso-21930-guidance/>
7. Precast/Prestressed Concrete Institute (PCI). 2019. *Specification for Glass-Fiber-Reinforced Concrete Panels*, ANSI/PCI 128.

