PCA®
America's Cement Manufacturers™

ASTM INTERNATIONAL

ENVIRONMENTAL PRODUCT DECLARATION

Portland Cements

(per ASTM C150, ASTM C1157, AASHTO M 85 or CSA A3001)

Committed to Sustainability

The United States cement industry is dedicated to manufacturing a superior product while constantly improving energy efficiency, minimizing emissions, and reducing environmental impacts.

This Environmental Product Declaration (EPD) was developed to document the environmental impacts of our products. Inside, you will find ASTM-certified, ISO-compliant information on cement's environmental footprint, including energy use and global warming potential. This is intended for business-to-business communication.

Our goal is to balance society's need for cement products with stewardship of the air, land, and water along with conservation of energy and natural resources.

Cement or Concrete?

Cement is actually an ingredient of concrete. It is the fine powder that, when mixed with water, sand, and gravel or crushed stone, forms the rock-like mass known as concrete.

Cement acts as the binding agent or glue. A chemical reaction called hydration is triggered when water and cement are mixed in the right proportions. This reaction causes the cement to harden and bind the aggregate into a solid mass.

When freshly mixed, concrete can be molded into almost any form. Yet when hardened, its strength and durability often exceed that of natural stone.

ASTM Certification page

This document is a Type III industry-average Environmental Product Declaration (EPD) describing portland cement produced in the United States (US). A list of cement production facilities who participated in the development of this EPD is included in Appendix A. The results of the underlying Life Cycle Assessment (LCA) are computed with the *U.S. version of WBCSD-CSI tool for EPDs of concrete and cement* (WBCSD-CSI 2016).

The EPD is certified by ASTM to conform to the Product Category Rule (PCR) referenced below, as well as to the requirements of ISO 14025 (ISO 2006a) and ISO 21930 (ISO 2007). ASTM also verifies that the life cycle assessment (LCA) upon which it is based conforms to the requirements of ISO 14040 (ISO 2006b).

DECLARATION HOLDER	Portland Cement Association 5420 Old Orchard Road, Skokie, IL, USA, 60077-1083 — www.cement.org
DECLARATION NUMBER	EPD 035
DECLARED PRODUCT	Portland cement
REFERENCE PCR	ASTM Product Category Rule for *Preparing an Environmental Product Declaration for Portland, Blended Hydraulic, Masonry, Mortar, and Plastic (Stucco) Cements.*
PROGRAM OPERATOR	ASTM International 100 Barr Harbor Drive, West Conshohocken, PA, USA, 19428-2959 — www.astm.org
DATE OF ISSUE	June 1, 2016
PERIOD OF VALIDITY	June 1, 2016 to May 31, 2021
NOTES	The EPD results are computed using the *U.S. version of WBCSD-CSI tool for EPDs of concrete and cement* (https://concrete-epd-tool.org).

EPD Verification			
This EPD has been certified by an independent, external verifier in accordance with ISO 14025.			
Christopher Surak Director of Certification Services ASTM	Date verified May 27, 2016	Jamie Meil Research Principal Athena Sustainable Materials Institute	Date verified May 27, 2016

PCR Information	
Program Operator	ASTM International
Reference PCR	Product Category Rules For Preparing An Environmental Product Declaration For Portland, Blended Hydraulic, Masonry, Mortar and Plastic (Stucco) Cements
Date of Issue	September 2, 2014
PCR Review was conducted by:	Nick Santero, PE International (rebranded as thinkstep), Chairperson Hamid Farzam, Cemex Anthony Fiorato, Consultant

Description of the product

The product under evaluation is portland cement as defined by ASTM C219 and specified in ASTM C150, ASTM C1157, AASHTO M 85 or CSA A3001.

Figure 1. portland cement

> A hydraulic cement produced by pulverizing clinker, consisting essentially of crystalline hydraulic calcium silicates, and usually containing one or more of the following: water, calcium sulfate, up to 5% limestone, and processing additions. (ASTM C219)

All cement products are composed of specific combinations of calcium, silica, iron and alumina and small amounts of additives to achieve a desired profile of properties (e.g., strength, color). Clinker, the principle intermediate manufactured product within cement production, is typically produced from a combination of ingredients, including limestone (for calcium), coupled with smaller quantities of materials such as clay, iron ore, and sand (as sources of alumina, iron, and silica, respectively). So common are these building blocks that a wide variety of raw materials are suitable sources, and some sources, such clay and fly ash, may provide multiple chemical components. Cement plants are increasingly turning to industrial byproducts that otherwise would be discarded, once completing detailed analyses to determine the effects of using a byproduct on the manufacturing process, cement performance and facility emissions.

Example sources of calcium, silica, iron and alumina are as follows:

Calcium sources – Chalk, clay, marble, seashells, shale, blast furnace slag

Silica sources – Clay, fly ash, loess, marl, ore washings, rice hull ash, sandstone, slag

Iron sources – Blast furnace flue dust, clay, mill scale, ore washings, shale

Alumina sources – Alumina ore refuse, clay, copper slag, fly ash, shale

The U.S. industry average portland cement, as found by this study, is 92.2% clinker by weight. Table 1 describes the cement's composition by specific material resources.

Table 1. Material composition of the U.S. industry average portland cement per mass of cement product.

Cement ingredient[a]	Portion of cement product (by weight)
Clinker	92.2%
Gypsum	4.63%
Uncalcined limestone	1.86%
Other materials	<1.0% each

[a] It should be noted that while all portland cement products contain the ingredients listed above, the average cement production data computed for this EPD represents the weighted average use of all materials by all participating plants. The data should not be interpreted to mean that the ratios presented in this table is the formulation for all portland cement products.

Declared unit

The declared unit for this study is the production of one metric tonne (1 t) of portland cement awaiting delivery to a customer. The cement is either packaged and stored on pallets or housed unpackaged in silos and ready for bulk transport.

System boundary

Life cycle stages

This EPD describes portland cement production from cradle-to-gate, as depicted in Figure 2. This includes all modules (A1-A3) of the Product stage, as defined by the PCR. Specifically, Product stage modules capture the following aspects of the life cycle:

- Extraction and processing of raw materials and packaging used to produce cement;
- Transportation of raw materials and packaging from source to cement production site;
- Consumption of energy and water required to produce cement;
- Emissions and wastes generated from producing cement;
- Transportation of wastes from cement production to end-of-life; and
- End-of-life of wastes generated during cement production.

The Construction, Use and End-of-life stages are excluded from the scope of the PCR and therefore from the impact data provided by this EPD.

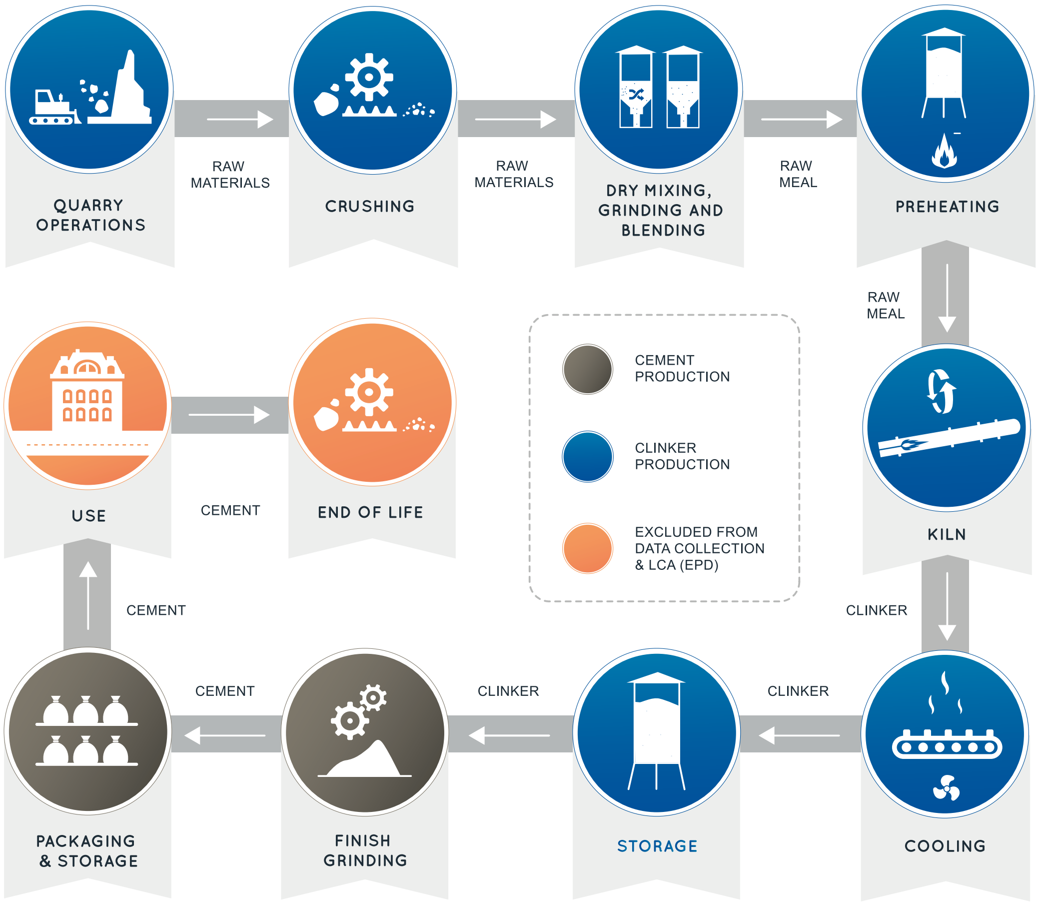

Figure 2. Boundary of the industry-average cement production processes.

Temporal and geographic boundaries

The portland cement production impacts estimated by the LCA represent cement produced in the US in 2014. Data and assumptions reflect equipment, processes and market conditions for this year. Background processes, such as quarry operations and electricity generation, are characterized by data that represent US processes where information is available. In cases where US-specific information is not available, the best available alternative information is used. Additional details describing the background data are provided in the *LCA core model and database report of the U.S. version of WBCSD-CSI tool for EPDs of concrete and cement.*

Exclusions and cut-off criteria

Several items are excluded from the foreground life cycle inventories (LCIs) used in the LCA. These relate specifically to operations at cement production plants:

> *Capital equipment and infrastructure.* These are expected to contribute negligibly (<1%) to the total impact of cement production given the long lifetime of these items and high output of cement over this period.
>
> *Personnel-related activities,* such as travel, furniture and office supplies. (Energy and water use related to on-site office operations, such as company management and sales activities, are included.)

These two categories of items are included in upstream processes (e.g., limestone quarrying, electricity generation) where they are captured in the background data used in the LCA.

Allocation approach

Allocation of inventory flows and subsequently environmental impact is relevant when assets are shared between product systems. The allocation method prescribed by the PCR is applied in the underlying LCA. For co-products, no credit is considered and no allocation is applied. See the *LCA core model and database report of the U.S. version of WBCSD-CSI tool for EPDs of concrete and cement* for more information.

Representation of the US cement industry

The life cycle impact assessment (LCIA) results presented by this EPD are calculated using an industry-average LCI of US portland cement production. The LCI is assembled with data shared by PCA members through a survey process carried out in 2015 and represents 2014 operations.

In 2014, the US cement industry generated 77,734,901 metric tonnes (85,688,036 tons) of portland cement (PCA 2015). The LCI captures 56,280,413 metric tonnes (62,038,518 tons) of PCA member production (as reported by 64 plants) and therefore 72.4% of total industry production in 2014.

Clinker technology

Clinker, the main ingredient in cement production, can be produced using one of a number of technologies, or a combination of these technologies. The portland cement described by this EPD is produced under the profile of clinker production technologies shown in Table 2.

Table 2. Clinker production technologies applied in the making of the portland cement described by this EPD.

Clinker production technology	Percent of cement produced by clinker technology
Dry with preheater and precalciner	77%
Dry with preheater	9%
Long dry	5%
Wet	1%
Other (other technology or a combination of technologies)[1]	8%

[1] As no other kiln technologies are known to exist in the US market, it is expected that participants selecting the "Other" category use a mixture of two or more of the four technologies listed in this table.

Electricity grid mix

For electricity use modeling, the PCR requires the use of subnational electricity consumption LCIs that consider power trading between regions. To do this, the US EPA's *eGrid* 2012 (US EPA 2015) data are used, which identify grid mixes for ten US regions (NERC regions) and considers regional trading. A weighted average of the NERC regional mixes is applied in the LCA, where the weighting reflects the portion of portland cement produced in each region. The resulting grid mix used in the LCA is shown in Table 3.

Table 3. Grid mix for portland cement production described by this EPD.

Energy source	Portion of representative grid mix
Coal and peat	35.53%
Gas	33.27%
Nuclear	16.57%
Hydro	8.18%
Wind	3.79%
Biomass	1.29%
Geothermal	0.56%
Oil	0.52%
Solar	0.14%
Waste	0.14%
TOTAL	**100%**

Data quality assessment

The data quality assessment performed here consists of (1) a review of the source of individual data shared by participating producers and (2) verification of the energy demand and Global warming potential calculated with the clinker production LCI. A full description of the quality assessment is provided in the PCA LCI report *Preparing industry average EPDs for cements produced in the United States. Life cycle inventories of portland, blended hydraulic, masonry and plastic (stucco) cements.*

The majority of data describing cement (and clinker) production is based on direct measurements and engineering calculations, as opposed to approximations. This is particularly true for flows that are the major contributors to impact for cement production, namely clinker production.

The clinker LCI is checked to ensure that an appropriate amount of energy use (cumulative energy demand) and Global warming potential are implied by the data. Both are accomplished by comparing the value computed with the LCI developed for the present LCA to those calculated with the U.S. average clinker production LCI provided by the International version of the *International version of WBCSD-CSI tool for EPDs of concrete and cement.* While it is not expected that the two values match exactly, it is expected that they are on the same order of magnitude, which is indeed the case. Differences are due to different types and quantities of fuels used within the two tools.

It should be noted that the data quality assessment here covers only the clinker and cement production inventories (i.e., activity data). An evaluation of the quality of data used to model background processes (e.g., electricity generation) has also been carried out, and the results are located in the *LCA core model and database report* of the *U.S. version of WBCSD-CSI tool for EPDs of concrete and cement.*

Limitations

This EPD represents average industry performance for producers of portland cement. It considers only cement plants located in the US, although some participating PCA members may operate plants elsewhere in the world. Results may not adequately represent cement production systems that differ greatly from those captured by the data used in the underlying LCA.

This EPD is a declaration of potential environmental impact and does not support or provide definitive comparisons of the environmental performance of specific products. Only EPDs prepared from cradle-to-grave life cycle results and based on the same function and reference service life and quantified by the same functional unit can be used to assist purchasers and users in making informed comparisons between products.

The EPD provided here and the underlying LCA conform to the ASTM Product Category Rule for *Preparing an Environmental Product Declaration for Portland, Blended Hydraulic, Masonry, Mortar, and Plastic (Stucco) Cements.* EPDs of portland cement that follow a different PCR may not be comparable.

LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. Further, LCA offers a wide array of environmental impact indicators, and this EPD reports a collection of those, as specified by the PCR.

In addition to the impact results, this EPD provides several metrics related to resource consumption and waste generation. While these data may be informational in other ways, they do not provide a measure of impact on the environment.

Additional information regarding LCA methodology

Additional information regarding databases and impact methodologies used for conducting the LCA for this EPD can be found in the *LCA core model and database report* of the *U.S. version of WBCSD-CSI tool for EPDs of concrete and cement.*

Life cycle assessment results

The cradle-to-gate impacts of producing portland cement are presented in Table 4.

Table 4. Life cycle results for portland cement production.

Metric	**Cradle-to-gate total per metric tonne of production**	**Unit**
Environmental impact		
Global warming potential (100 years)	1040	kg CO2-eq.
Acidification potential	2.45	kg SO2-eq.
Eutrophication potential	1.22	kg N-eq.
Formation potential of tropospheric ozone	48.8	kg O3-eq
Ozone depletion potential	2.61E-05	kg CFC 11-eq.
Total primary energy consumption		
Non-renewable primary energy: Fossil	5250	MJ
Non-renewable primary energy: Nuclear	345	MJ
Renewable primary energy: Solar, wind, hydroelectric, geothermal	127	MJ
Renewable primary energy: Biomass	165	MJ
Material resources consumption		
Non-renewable material resources	1420	kg
Renewable material resources	7.64	kg
Net fresh water[a]	9700	L
Total waste generation[b]		
Non-hazardous waste generated	8.99	kg
Hazardous waste generated	0.0518	kg

[a] The result provided here should be interpreted as water withdrawal rather than water consumption.

[b] The waste metrics include only wastes generated at clinker and cement production plants.

Additional environmental information

Some additional information is provided here to further describe the production of portland cement. This includes implementation of ISO 14001 across the participating plants as well as a summary of recovered material use and direct water use during clinker and cement production. The latter two are provided in Table 5.

Of the responding plants, 19 affirm to be in conformance with ISO 14001 (ISO 2015). These plants produce approximately 25% of the portland cement captured by the industry-average LCI used in the underlying LCA.

Table 5. Summary of recovered material use and on-site water use during portland cement production.

Metric[a]	Cradle-to-gate total per metric tonne of production[b]	Unit
Recovered materials used as materials	142	kg
Recovered materials used as fuels	518	MJ (HHV[c])
Freshwater use (on-site withdrawal only)	853	L

[a] Not provided by the *U.S. version of WBCSD-CSI tool for EPDs of concrete and cement.* Calculated manually using the LCI results.

[b] Includes only direct use during clinker and cement production.

[c] Calculation based on the higher heating value (HHV) of fuels.

References

ISO (2006a) Environmental labels and declarations — Type III environmental declarations — Principles and procedures ISO 14025:2006. Geneva, Switzerland.

ISO (2006b) Environmental management — Life cycle assessment — Requirements and guidelines. ISO/TR 14044:2006. Geneva, Switzerland.

ISO (2007) Sustainability in building construction — Environmental declaration of building products. ISO 21930:2007. Geneva, Switzerland.

ISO (2015) Environmental management systems — Requirements with guidance for use. ISO 14001:2015. Geneva, Switzerland.

PCA (2014) Labor-Energy Input Survey. http://www.cement.org/market-economics/more-reports.

US EPA (2015) eGRID 2012. The Emissions and Generation Resource Integrated Database. http://www.epa.gov/energy/egrid.

World Business Council for Sustainable Development Cement Sustainability Initiative (WBCSD-CSI) (2016). *U.S. version of WBCSD-CSI tool for EPDs of concrete and cement*. https://concrete-epd-tool.org/.

Appendix A: Participating PCA members

Special thanks is given to PCA industry members who made possible the development of this EPD by providing information about their cement production operations. These companies are listed in Table 6.

Table 6. Participating PCA member companies.

Member	Corporate headquarters	Website
Alamo Cement Company	Bethlehem, PA	buzziunicemusa.com
Argos USA Corp.	Alpharetta, GA	argos.co/usa
Ash Grove Cement	Overland Park, KS	ashgrove.com
Buzzi Unicem USA	Bethlehem, PA	buzziunicemusa.com
CalPortland Company	Glendora, CA	calportland.com
Capitol Aggregates, Inc.	San Antonio, TX	capaggltd.com
Cemex	Houston, TX	cemexusa.com
Continental Cement	Chesterfield, MO	continentalcement.com
Drake Cement	Scottsdale, AZ	drakecement.com
Essroc	Nazareth, PA	essroc.com
GCC of America	Glendale, CO	gccusa.com
LafargeHolcim	Rosemont, IL	lafargeholcim.com
Lehigh Hanson	Irving, TX	lehighhanson.com
Lehigh White Cement	Allentown, PA	lehighwhitecement.com
Martin Marietta Materials, Inc.	Dallas, TX	martinmarietta.com
Mitsubishi Cement Corporation	Henderson, NV	mitsubishicement.com
Monarch Cement Company	Humboldt, KS	monarchcement.com
National Cement Group	Encino, CA	nationalcement.com
Salt River Materials Group	Scottsdale, AZ	srmaterials.com
St. Marys Cement	Toronto, ON	stmaryscement.com
Suwannee American Cement	Branford, FL	suwanneecement.com
Titan America LLC	Norfolk, VA	titanamerica.com

PCA link to download the document:

www.cement.org/epd

About PCA

PCA has been a widely-recognized authority on the technology, economics, and applications of cement and concrete for 100 years. Representing America's cement manufacturers, PCA is a vocal advocate for sustainability, economic growth, sound infrastructure investment, and overall innovation and excellence in construction. More information on PCA is available at www.cement.org.

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