NSF/ASTM 1126-23

Product Category Rule for Environmental Product Declarations

PCR for Construction Aggregates

Program Operator
NSF International
National Center for Sustainability Standards
Valid through September 30, 2027
ncss@nsf.org




PCR REVISION HISTORY

Version	Date issued
Version 1 (published by ASTM)	January 2017
Extension	February 2022
Extension	February 2023
Version 2	December 2023

Published by
NSF International
P.O. Box 130140, Ann Arbor, Michigan 48113-0140, U.S.A.

Printed in the United States of America.




PRODUCT CATEGORY RULES REVIEW PANEL

Program Operator

NSF International

Recommended for adoption by

The PCR Committee for Construction Aggregates

Expert Review Panel

Dr. Thomas P. Gloria, Ph.D
Industrial Ecology Consultants
35 Bracebridge Road
Newton, MA 02459 U.S.A.
t.gloria@industrial-ecology.com

Jack Geibig
EcoForm
2624 Abelia Way, Suite 611
Knoxville, TN 37931 U.S.A.
jgeibig@ecoform.com

Bill Stough
Bill Stough, LLC
822 Cherry SE, Suite 203
Grand Rapids, MI 49506 U.S.A.
bill@billstough.net

PCR review panel comments may be obtained by contacting NSF International's National Center for Sustainability Standards at ncss@nsf.org.

NSF International shall ensure that reasonable balance among the members of a PCR committee is achieved and potential conflicts of interest were resolved prior to commencing this PCR development. No participation fees will be charged by NSF International to interested parties for participation on PCR Development Committees, for attendance at PCR Development Committee meetings, or for commenting on a draft PCR document.




ABOUT NSF'S NATIONAL CENTER FOR SUSTAINABILITY STANDARDS (NCSS)

Through the National Center for Sustainability Standards, NSF develops life cycle based, multi-attribute sustainability standards, protocols, and PCRs for various industries including building products and materials, furniture, carpet and flooring, fabrics, wallcoverings, roofing membranes, green chemicals, and water and wastewater.

The National Center for Sustainability Standards will continue to add to its growing portfolio while providing education, outreach, and innovative support to private industry, trade associations, government and academia to foster a consensus-based approach toward conformity assessment in the sustainability field. Visit <www.nsfsustainability.org> or contact ncss@nsf.org.

To initiate your LCA, receive your EPD verification, or have questions on where to start, contact NSF Sustainability at sustainability@nsf.org or 734-476-2543.




CONTENTS

PCR DEVELOPMENT AND STAKEHOLDER CONSULTATION

This product category rule for “construction aggregates” is Version 2 of the Product Category Rules (PCR) for ISO 14025:2006 Type III Environmental Product Declarations (EPDs) of natural aggregates, crushed concrete, and iron/steel furnace slag, updating Version 1 dated January 2017, published by ASTM.

The following changes have been included in this document:

- renewed and updated to include conformance with ISO 21930 (2017);
- unbound asphalt is included in Version 2 of this PCR;
- the title of the PCR has been modified to “PCR for Construction Aggregates”;
- updated to include specific information on upstream data included in Annex A; and
- an underlying LCA has been completed to complement this PCR.

A committee outlined in Annex C provided review and input to the revisions. After consideration of existing North American PCR for construction aggregates and ISO 21930:2017 (see references) the technical committee decided to use ISO 21930:2017 as the ‘core PCR’ and adapt the ASTM construction aggregates PCR to be a ‘subcategory PCR’. ISO 21930:2017 provides the core rules for construction products and services and must be read in tandem with this document.

For information about PCR development and stakeholder consultations, see Annex C.

The development of this PCR was supported by the National Stone, Sand, and Gravel Association and its members.

A note on EPD ownership, liability and responsibility, and included by reference in Section 5.4 of this document: Per ISO 21930 Clause 5.4, a manufacturer or a group of manufacturers are the sole owners and have liability and responsibility for an EPD, including but not limited to insuring industry wide and manufacturer specific EPD updates are made based on the most recent LCA modelling software version and impact assessment version available. Only the manufacturer or group of manufacturers is authorized to declare the environmental performance of the construction product using an EPD.




1 SCOPE

Per ISO 21930:2017 Clause 1, with the following additions:

While this PCR will be used primarily in North America, it may be used in other regions where program operators deem it appropriate.

This PCR applies to conventional construction aggregate, a processed granular material where the main form of processing is through a series of blasting, crushing, screening, washing, and/or other mechanical classifying equipment to properly size the finished product for use as a construction aggregate. Construction aggregates are generally used to produce concrete or asphalt mixtures, but are also commonly used directly as aggregate base, stabilizing aggregates, fill, or other unbound functions. This PCR enables the development of EPDs associated with the production of construction aggregates from cradle-to-gate for life cycle stage Modules A1 to A3. Table 1.1 lists applicable standards and specifications for this PCR.

Table 1.1
Aggregates and related standards

Aggregate	Related standards
aggregates for concrete	ASTM C33/C33M, *Standard Specification for Concrete Aggregates*
	ASTM C125, *Standard Terminology Relating to Concrete*
	ASTM C144, *Standard Specification for Aggregate for Masonry Mortar*
	ASTM C637, *Standard Specification for Aggregates for Radiation-Shielding Concrete*
	ASTM C1797, *Standard Specification for Ground Calcium Carbonate and Aggregate Mineral Fillers for Use in Hydraulic Cement Concrete*
	CSA A23.1/A23.2, *Concrete materials and methods of concrete construction*




Table 1.1
Aggregates and related standards

Aggregate	Related standards
Aggregates for asphalt mixtures	ASTM D8, *Standard Terminology Relating to Materials for Road and Pavements*
	ASTM D692/D692M, *Standard Specification for Coarse Aggregate for Bituminous Paving Mixtures*
	ASTM D1073, *Standard Specification for Fine Aggregate for Bituminous Paving Mixtures*
	ASTM D1139/D1139M, *Standard Specification for Aggregate for Single or Multiple Bituminous Surface Treatments*
	ASTM D5106, *Standard Specification for Steel Slag Aggregates for Bituminous Paving Mixtures*
	ASTM D6155, *Standard Specification for Nontraditional Coarse Aggregates for Asphalt Paving Mixtures*
Unbound aggregates	ASTM D2940/D2940M, *Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports*
	ASTM D4992, *Standard Practice for Evaluation of Rock to be Used for Erosion Control*
	ASTM D6092, *Standard Practice for Specifying Standard Sizes of Stone for Erosion Control*
	ASTM D6711, *Standard Practice for Specifying Rock to Fill Gabions, Revet Mattresses and Gabion Mattresses*

NOTE 1 — This PCR does not cover expanded shale, clay, and slate lightweight aggregates as a separate PCR already exists that covers the full production process for those materials. <www.shopulstandards.com/ProductDetail.aspx?productId=ULE10010-37_2_S_20220125>

NOTE 2 — This PCR does not cover alternative types of aggregates, e.g., recovered glass and rubber.




2 NORMATIVE REFERENCES

The following documents are referred to in the text in such a way that some or all of their content constitutes the requirements of this document. For updated references, the latest edition of the referenced documents (including any amendments) applies:

ASTM C33/C33M, *Standard Specification for Concrete Aggregates*[1]

ASTM C125, *Standard Terminology Relating to Concrete and Concrete Aggregates*[1]

ASTM C144, *Standard Specification for Aggregate for Masonry Mortar*[1]

ASTM C637, *Standard Specification for Aggregates for Radiation-Shielding Concrete*[1]

ASTM C1797, *Standard Specification for Ground Calcium Carbonate and Aggregate Mineral Fillers for Use in Hydraulic Cement Concrete*[1]

ASTM D8, *Standard Terminology Relating to Materials for Road and Pavements*[1]

ASTM D692/D692M, *Standard Specification for Coarse Aggregate for Bituminous Paving Mixtures*[1]

ASTM D1073, *Standard Specification for Fine Aggregate for Asphalt Paving Mixtures*[1]

ASTM D1139/D1139M, *Standard Specification for Aggregate for Single or Multiple Bituminous Surface Treatments*[1]

ASTM D2940/D2940M, *Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports*[1]

ASTM D4992, *Standard Practice for Evaluation of Rock to be Used for Erosion Control*[1]

ASTM D5106, *Standard Specification for Steel Slag Aggregates for Bituminous Paving Mixtures*[1]

[1] ASTM International. 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959. <www.astm.org>




ASTM D6092, *Standard Practice for Specifying Standard Sizes of Stone for Erosion Control*[1]

ASTM D6155, *Standard Specification for Nontraditional Coarse Aggregates for Asphalt Paving Mixtures*[1]

ASTM D6711, *Standard Practice for Specifying Rock to Fill Gabions, Revet Mattresses, and Gabion Mattresses*[1]

CSA A23.1/A23.2, *Concrete materials and methods of concrete construction/Test methods and standard practices for concrete*[2]

ISO 14025:2006, *Environmental Labels and Declarations — Type III Environmental Declarations — Principles and Procedures*[3]

ISO 14040:2006/AMD 1:2020, *Environmental Management – Life Cycle Assessment – Principles and Framework*[3]

ISO 14044:2006/AMD 1:2007/AMD 2:2020, *Environmental Management – Life Cycle Assessment – Requirements and Guidelines*[3]

ISO 21930:2017, *Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services*[3]

3 TERMS AND DEFINITIONS

Per ISO 21930:2017 Clause 3, with the following additions:

aggregate: Granular material of mineral composition such as sand, gravel, shell, slag or crushed stone used with a cementing medium to form mortars or concrete, or alone as in base courses, railroad ballasts, etc. [ASTM D8, ASTM C125]

background data / secondary data: Indirectly measured, calculated, or obtained quantified value of a unit process or activity and related information within a product system (ISO 14040:2006, Section 3.28) or organization, not based on specific original source measurements. [ISO 21930]

[2] CSA Group. 178 Rexdale Boulevard, Toronto, ON M9W 1R3, Canada. <www.csagroup.org>

[3] International Organization for Standardization. Chemin de Blandonnet 8, Case Postale 401, 1214 Vernier, Geneva, Switzerland. <www.iso.org>




blast-furnace slag: The nonmetallic product consisting essentially of silicates and alumino-silicates of lime and other bases, that is developed simultaneously with iron in a blast furnace. [ASTM D8]

coarse aggregate: *(1)* Aggregate predominantly retained on the 4.75-mm (No. 4) sieve; or *(2)* that portion of an aggregate retained on the 4.75-mm (No. 4) sieve. [ASTM C125]

> NOTE — The definitions are alternatives to be applied under differing circumstances. Definition *(1)* is applied to an entire aggregate either in a natural condition or after processing. Definition *(2)* is applied to a portion of an aggregate. Requirements for properties and grading should be stated in the specification.

facility-specific EPD: EPD result developed by a manufacturer for a specific manufacturing facility location using relevant foreground data.

> NOTE — This may be for a single product, multiple products or average(s) of product type(s) at a facility.

fine aggregate: *(1)* Aggregate passing the 9.5-mm ($^3/_8$-in) sieve and almost entirely passing the 4.75-mm (No. 4) sieve and predominantly retained on the 75-µm (No. 200) sieve; or *(2)* that portion of an aggregate passing the 4.75-mm (No. 4) sieve and retained on the 75-µm (No. 200) sieve. [ASTM C125]

> NOTE — The definitions are alternatives to be applied under differing circumstances. Definition *(1)* is applied to an entire aggregate either in a natural condition or after processing. Definition *(2)* is applied to a portion of an aggregate. Requirements for properties and grading should be stated in the specifications.

foreground data / primary data: Quantified value of a unit process or an activity obtained from a direct measurement, or a calculation based on indirect measurements at its original source. [ISO 21930]

hazardous waste: Waste identified as hazardous according to regulations applicable in the market for which the EPD is valid. For the U.S. market, wastes are hazardous if they are regulated under the Resource Conservation and Recovery Act.[4] See also 40 C.F.R. 261.33.[5] For the Canadian market, wastes are hazardous if they are regulated under the Canadian Environmental Protection Act, 1999 Regulations.[6]

---

[4] <www.epa.gov/rcra>

[5] <www.govinfo.gov/content/pkg/CFR-2011-title40-vol26/pdf/CFR-2011-title40-vol26-sec261-33.pdf>

[6] <www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/permit-hazardous-wastes-recyclables/management.html>




NOTE — Hazardous waste does not include radioactive waste; see ISO 21930:2017 Clause 7.2.14.

heavyweight aggregate: See ASTM C125.

industry-wide average EPD: EPD results for a specific product or group of aggregates categorized by performance for a specified region and/or group of manufacturers.

lightweight aggregate: See ASTM C125.

nonhazardous waste: Commercial / industrial waste that is not hazardous: dust, spoil, or other waste from raw material extraction; waste in municipal disposal scheme, and leftover or waste cement.

normal-weight aggregate: See ASTM C125.

product-specific EPD: EPD results for a specific product or group of aggregates, categorized by performance and developed by a manufacturer for a specific manufacturing facility location(s).

NOTE — This may be for a single facility or averages across multiple facilities.

recovered material: Material that would have otherwise been disposed of as waste or used for energy recovery but has instead been collected and recovered as a material input, instead of a new primary material, for a recycling or a manufacturing process. [ISO 14021]

reclaimed asphalt pavement (RAP) aggregates: Asphalt pavement or paving mixture removed from its original location for use in recycled asphalt mixture (ASTM D8-21). In the context of this PCR, RAP can also be used as a conventional construction aggregate sometimes referred to as “unbound asphalt aggregate” or “RAP-aggregates”

steel slag: The nonmetallic product consisting of essentially calcium silicates and ferrites combined with fused oxides of iron, aluminum, manganese, calcium and magnesium, that is developed simultaneously with steel in basic oxygen, electric or open-hearth furnaces. [ASTM D8]

4 ACRONYMS AND ABBREVIATED TERMS

Per ISO 21930:2017 Clause 4, with the following additions:

ACLCA	American Center for Life Cycle Assessment
ANFO	ammonium nitrate fuel oil
B2B	business-to-business
B2C	business-to-consumer
EPD	environmental product declaration
EUOFER	European Steel Association
FERC	Federal Energy Regulatory Commission
FLCAC	Federal Life Cycle Assessment Commons (aka “The Commons”)
GCCA	Global Cement and Concrete Association
GHG	greenhouse gas
GWP	global warming potential
ISO	International Standards Organization
LCA	life cycle assessment
LCI	life cycle inventory
LCIA	life cycle impact assessment
NETL	National Energy Technology Laboratory – A division of the Department of Energy (DOE)
NRMCA	National Ready-Mix Concrete Association
PCR	product category rule
POCP	photochemical ozone creation potential
PPA	power purchase agreements
RAP	reclaimed asphalt paving
RCA	recycled concrete aggregate
REC	renewable energy credit
RSL	reference service life
TRACI	Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts
USLCI	United States Life Cycle Inventory




5 GENERAL ASPECTS

5.1 Objectives of this PCR

Per ISO 21930:2017 Clause 5.1, with the following additions:

The primary objective of this subcategory PCR is to provide rules for the application of ISO 21930:2017 to create Type III EPDs for construction aggregate products identified in Table 1.1 of this PCR.

Additional objectives include:

- accurately assess the emissions and environmental aspects associated with aggregates production;
- provide a means for aggregate producers and other stakeholders to use EPDs as a tool to benchmark the environmental aspects and potential environmental impacts of aggregate production;
- encourage the publication and use of upstream LCA data associated with materials and resources used in aggregate production;
- promote consistency of EPDs for aggregates with applicable guidance related to PCRs and EPDs for affiliated materials;
- ensure that EPDs for aggregates are eligible to earn credit under green rating systems and green construction codes; and
- enable the use of EPDs for aggregates as a data source for conducting LCA of horizontal and vertical projects to compare potential life cycle environmental impacts of different designs.

5.2 Life cycle stages and their information modules and Module D

Per ISO 21930:2017 Clause 5.2, with the following clarifications:

This PCR establishes requirements for the assessment and reporting of life cycle impacts associated with the production of construction aggregates identified in Section 1. As such, all EPDs developed to this PCR shall be cradle-to-gate in scope as defined in ISO 21930 Clause 5.2.2. The scope of the underlying LCA of construction aggregates is strictly cradle-to-gate, with the gate being defined as the point at which the aggregate is transferred to a vehicle for transport to the customer (the last point of the producer's control). Additional life cycle stages or information modules shall not be included in EPDs developed under this sub-category PCR.

Reasoning: Construction aggregates are constituents of many composite materials such as concrete and asphalt mixtures. To that end, aggregate producers have limited knowledge of the subsequent use of the product after it leaves the gate and accordingly aggregate producers do not have sufficient information to provide for the lifecycle stages beyond the gate.

5.3 Average EPDs for groups of similar products

Per ISO 21930:2017 Clause 5.3, with the following clarifications:

Industry average EPDs may also be developed for groups of similar products using average environmental performance data. Requirements for industry average EPDs given in ISO 21930:2017 Clause 5.3 shall apply, with the following additions:

- for greater transparency, product specific EPDs are recommended;
- examples of average EPD groupings for construction aggregate products include, but not be limited to:
    - type of geologic material extracted (e.g., hardrock, limestone, alluvial deposit, etc.);
    - type of aggregate processing method (e.g.,drill-and-blast, dredging, underground, etc.);
    - type of aggregate (ballast, structural fill, base, sized construction aggregate, rip rap, recycled aggregate, slag aggregate);
    - washed versus unwashed products;
    - size category (e.g., inch/mm category, boulder size, etc.); and
    - rules specific to averaging are spelled out in ISO 21930 Clause 5.3, particularly regarding plant and product grouping. In all cases, the average must be carried out using a weighted average based on the annual production. Industry average EPDs shall indicate which method is used to calculate each information module (A1 to A3). In the cases where plant grouping averages are reported, the EPD must include the geographic range of the production facilities.

- Manufacturers seeking to align their individual Type III EPDs against an industry-wide average EPD shall have participated in the industry-wide average EPD. Alternatively, for manufacturers not included in the initial industry-wide average EPD, to be included retroactively in the industry-wide average EPD, the program operator, LCA practitioner, primary sponsor of the initial industry-wide average EPD, and manufacturer shall confer to reach a consensus on how to proceed. The effect of the additional EPD on the industry-wide average shall be estimated and the EPD updated.

5.4 Use of EPDs for construction products

Per ISO 21930:2017 Clause 5.4, with the following clarifications and additions:

This PCR is intended to be used to create EPDs for use in B2B communication. If the EPD is intended for use in the B2C marketplace, the provisions of ISO 14025:2006 Section 9 apply.

The manufacturer, or group of manufacturers, of the construction product is the sole owner of the EPD and is responsible for developing the EPD of the construction product according to this PCR. Only the manufacturer or group of manufacturers is authorized to declare the environmental performance of the construction product using an EPD.

5.5 Comparability of EPDs for construction products

Comparison of construction products using an EPD shall be carried out in the context of the construction works. Consequently, a comparison of the environmental performance of the construction products using the EPD shall consider all the relevant information modules over the full life cycle of the product within the construction works. Requirements for comparability of EPDs given in ISO 21930:2017 Clause 5.5 shall apply, with the following clarifications:

- comparison based on LCA A1. A3 data shall be made only if the same background data sets and declared units are equivalent for both EPDs;
- for product specific EPDs, comparisons should only be made between products that perform similarly in their final applications; and
- for product specific EPD comparisons, results for A2 transportation reflect actual transportation distances.

The following statement will be required for all EPDs produced using this PCR:

"This EPD meets all comparability requirements stated in ISO 14025:2006. However, differences in certain assumptions, data quality, and variability between LCA data sets may still exist. As such, caution should be exercised when evaluating EPDs from different manufacturers or programs, as the EPD results may not be entirely comparable. Any EPD comparison must be carried out at the construction works level per ISO 21930:2017 guidelines. The results of this EPD reflect an average performance by the product and its actual impacts may vary on a case-to-case basis."




5.6 Documentation

Per ISO 21930:2017 Clause 5.6. See PCR Section 8 for additional guidance.

6 PCR DEVELOPMENT AND USE

Per ISO 21930:2017 Clause 6, with the following additions:

This PCR document is effective for five (5) years from the latest date of publication. If, after five years, relevant changes in the product category or other relevant factors have occurred (for example, the evolution of LCA methodology in ISO 21930:2017), the document will be revised. See Section 5.5 for comparability.

7 PCR FOR LCA

7.1 Methodological framework

7.1.1 LCA Modeling and calculation

Per ISO 21930:2017 Clauses 7.1.1, and 7.2.3 through 7.2.6.

7.1.2 Functional unit

Per ISO 21930:2017 Clause 7.1.2, with the following clarification:

The functional unit defines how the identified functions and performance characteristics of the product are quantified. Requirements for the functional unit given in ISO 21930:2017 Clause 7.1.2, shall apply, with the following modifications:

Because these PCR for construction aggregates cover only the cradle-to-gate stages, the use of a functional unit is not applicable. See Section 7.1.3 for additional guidance.

7.1.3 Declared unit

Per ISO 21930:2017 Clause 7.1.3, with the following clarification:

A declared unit provides a reference by which a product is normalized to produce data expressed on a common basis and is appropriate when the precise function of the product at the construction works is not stated or within scope. The requirements for establishing a declared unit given in ISO 21930:2017 Clause 7.1.3 shall apply, with the following clarifications.

An EPD prepared to this PCR covers only the cradle-to-gate life-cycle stages (A1-A3). Since the use phase is explicitly excluded from this scope, a declared unit shall be used. The declared unit shall be one U.S. customary ton (2,000 lb) (0.907 metric tonne) of aggregate that is ready for shipment. In addition, data shall also be additionally provided per metric tonne (1,000 kg) of aggregate.

7.1.4 Requirements for the use of the reference service life

The RSL of a product defines the expected service life of a product under a specific set of use conditions. Requirements given in ISO 21930:2017 Clause 7.1.4 shall apply, with the following clarifications.

As this PCR does not address Module B (Use), the RSL of construction aggregates is not applicable.

7.1.5 System boundary with nature

Per ISO 21930:2017 Clause 7.1.5.

7.1.6 System boundary between product systems

Per ISO 21930:2017 Clause 7.1.6, with the following additions.

In the steel industry, the chemistry of the slag is used to control the properties of the steel during production. Therefore, it has been designated as a co-product. Co-products generated during steel mill operations are allocated using a method developed by World Steel Association and EUOFER to be in line with CEN EN 15804 (CEN, 2019). The slag allocation factor is detailed in Annex A.

In the case of slag, a product of steel and iron production, economic allocation shall be used to allocate flows to the slag at the iron or steel production facility.




The end-of-life for asphalt and concrete is removing these materials from their installed location, whether that be a road or structure. These materials are removed by either road stripping, demolition or by other methods and placed into an initial stockpile. The EPD related burdens associated with the end-of-life for asphalt and concrete are to be accounted for in their respective PCR's. All EPD related burdens from the initial RAP and broken concrete stockpiles onward are accounted for in the aggregates PCR see Section 7.1.7.

7.1.7 System boundaries and technical information for scenarios

Per ISO 21930:2017 Clause 7.1.7, with the following additions.

Figure 1 shows the life-cycle stages broken out by modules as defined by ISO 21930. This PCR covers the production stage of construction aggregates, which includes modules A1 to A3 in Figure 1. As such, an EPD developed to this PCR shall be cradle-to-gate in scope. EPD scopes inclusive of other modules and life cycle stages are prohibited.




Construction works assessment information														
Construction works life cycle information within the system boundary														Optional supplementary information beyond the system boundary
A1 – A3			A4 – A5		B1 – B7					C1 – C4				D
PRODUCTION stage (mandatory)			CONSTRUCTION stage		USE stage					END-OF-LIFE stage				
A1	A2	A3	A4	A5	B1	B2	B3	B4[1]	B5	C1	C2	C3	C4	
Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance (including production, transport, and disposal of necessary materials)	Repair (including production, transport, and disposal of necessary materials)	Replacement (including production, transport, and disposal of necessary materials)	Refurbishment (including production, transport, and disposal of necessary materials)	Deconstruction / demolition	Transport to waste processing or disposal	Waste processing	Disposal of waste	Potential net benefits from reuse, recycling, and/or energy recovery beyond the system boundary
			scenario	*scenario*	*scenario*	*scenario*	*scenario*	*scenario*	*scenario*	*scenario*	*scenario*	*scenario*	*scenario*	*scenario*
					B6	Operational energy use								
					scenario									
					B7	Operational water use								
					scenario									

[1] Replacement information module (B4) not applicable at the product level.

A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	optional

Figure 1

Common four life cycle stages and their information modules [Source: 21930:2017]

Figure 2 shows a functional breakdown of a typical aggregate operation and specifically shows cutoff boundaries, and the assignment of inputs to stages A1 to A3 as well as product outputs.

NOTE — Not all products go through all steps in processes shown in Figure 2.

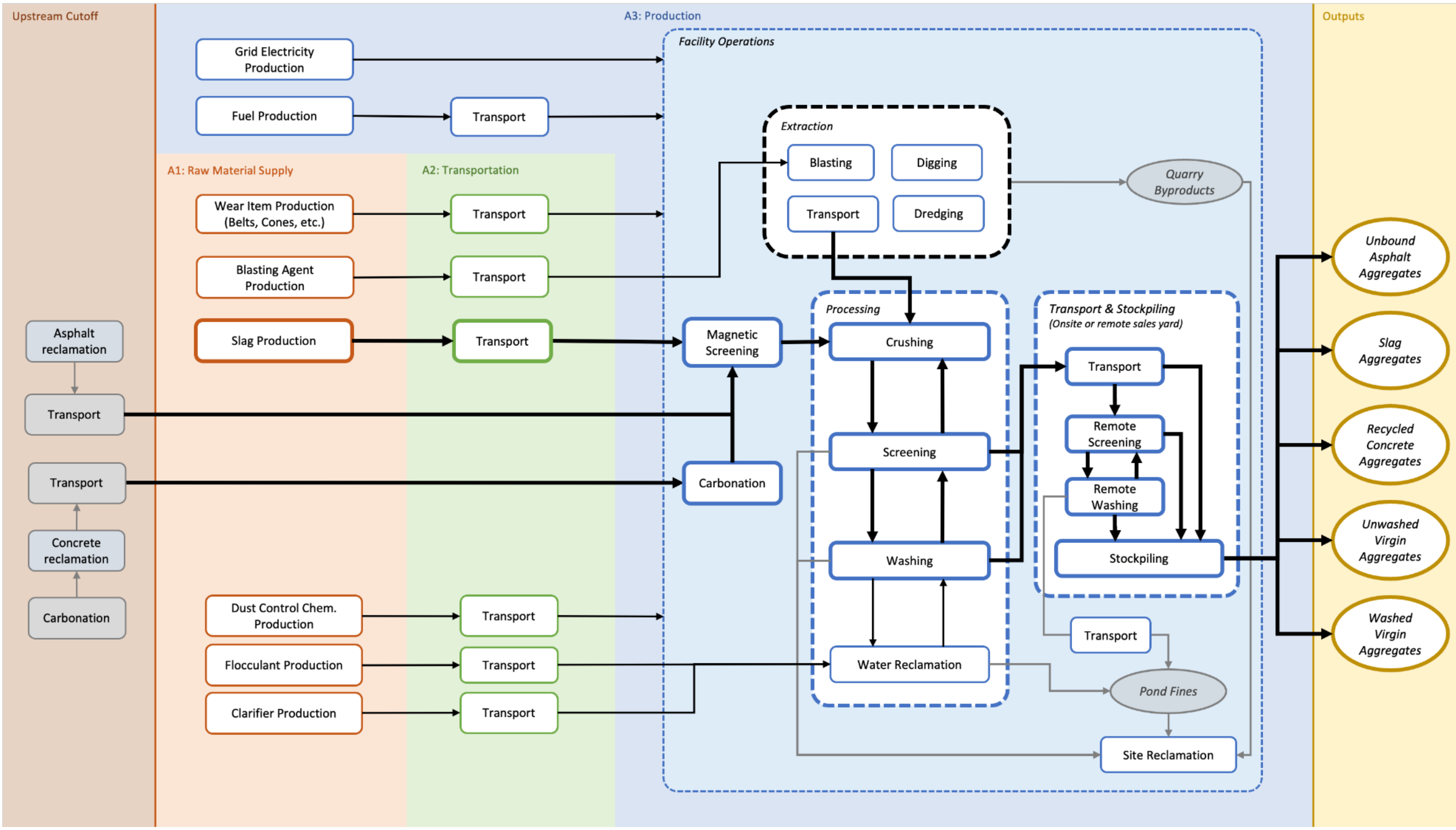


Figure 2

Process flow diagram




This section of the PCR details the processes and flows to be considered for each module. Specific items that may be excluded from the system boundary include:

- production, manufacture, and construction of manufacturing capital goods and infrastructure;
- production and manufacture of production equipment, delivery vehicles, and laboratory equipment;
- personnel-related activities (travel, furniture, and office 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.

7.1.7.1 General

Per ISO 21930:2017 Clause 7.1.7.1, with the following modifications.

Since the scope of an EPD developed to this PCR is limited to cradle-to-gate, scenario data for modules other than A1-A3 are not applicable and thus shall not be reported.

7.1.7.2 A1-A3, production stage

Per ISO 21930:2017 Clause 7.1.7.2, with the following modifications.

Module A1 shall rely on background data/upstream data that are specified in Annex A. The module shall include impacts associated with the following processes:

- production and transmission of water;
- production of explosives;
- Production of supplemental chemicals (e.g., flocculants and coagulants, etc.);
- slag production. Slag is a co-product of steel production and is assigned an economic allocation based on steel industry data. See Section 7.2.5.2 or further details; and
- production of wear items (e.g., crusher cones, etc.).

Module A2 – Transportation to the processing plant shall include empty backhauls and transportation to interim distribution centers or terminals. Data sources for backhauls shall be cited, e.g., U.S. Life Cycle Inventory Database,[7] or alternatively, methods used to account for empty backhauls shall be described.

[7] <https://www.nrel.gov/lci/>

Impacts associated with A2 shall include:

- transportation of wear parts to the processing plant;
- transportation of blasting agents, dust control chemicals, flocculants, and all other process-related chemicals to the processing plant;
- transportation of slag aggregate to the processing plant; and
- transportation of broken concrete and reclaimed asphalt if coming to the processing facility from an external stockpile or storage area other than the processing plant.

Module A3 requirements shall include but are not limited to:

- blasting, digging, dredging and transporting of aggregate from source to the processing plant;
- crushing, screening, and stockpiling;
- transportation of all materials within the processing plant;
- aggregate washing and dust control (see Section 7.1.7);
- operation of water clarification system and handling of fines;
- placement of fines; and
- overburden stripping, handling and placement.

NOTE — Module A3 impacts (listed above) calculations shall rely on background / upstream data found in Annex A for the generation of electricity, steam and heat from primary energy resources used in manufacturing, including their extraction, refining and transport.

Module A1, A2, and A3 shall be reported separately as well as in total A1-A3.

7.1.7.3 A4-A5, construction stage

This section of ISO 21930:2017 does not apply.

7.1.7.4 Use stage

This section of ISO 21930:2017 does not apply.




7.1.7.5 End-of-life stage

This section of ISO 21930:2017 does not apply.

7.1.7.6 Benefits and loads beyond the system boundary

Where relevant, Module D information declares potential loads and benefits of secondary material, secondary fuel, or recovered energy leaving the product system based on scenarios. Because the construction aggregates are used as constituents in a variety of applications, their end-of-life benefits are not known with certainty and are therefore not included in this PCR. It is noteworthy, however, that aggregates are typically recycled and reused and rarely landfilled. Such benefits are not typically associated with the manufacture of construction aggregates, thus the requirements of Section ISO 21930:2017 Clause 7.1.7.6 are deemed out of scope and shall not apply.

7.1.8 Criteria for the inclusion and exclusion of inputs and outputs

Per ISO 21930:2017 Clause 7.1.8 shall apply.

7.1.9 Selection of data and data quality requirements

Per ISO 21930:2017 Clause 7.1.9 shall apply, with the following exceptions.

7.1.9.1 Foreground data

7.1.9.1.1 Time period

Facility-specific datasets (A3) shall include 12 consecutive months of data beginning within five years of the publication date of the EPD. Deviations shall be justified.

For transparency, the time period for collection of foreground data should be reported in EPDs as specified in Section 9.2.

If the market-based method for Scope 2 accounting is used to quantify potential GHG emission reductions associated with electricity consumption and reported as additional environmental information (see Section 8.3), documentation shall meet the Scope 2 Quality Criteria in the GHG Protocol Scope 2 Guidance.




7.1.9.1.2 Documents on file

Foreground data shall be based on utility and energy bills, sales records, product designs, and similar records, all of which should be kept on file and easily accessible. Deviations shall be justified.

7.1.9.1.3 Geography

Foreground data for a facility-specific EPD shall be specific to the facility. Company averages are not allowed. Foreground data for industry average EPDs shall be specific to the participating facilities and products that meet the applicable specification(s).

7.1.9.1.4 Data gaps

Data gaps for foreground data shall be limited only to those items for which a predetermined parameter has been provided in Annex A. Deviations shall be justified.

7.1.9.2 Background data

7.1.9.2.1 Prioritization of data for upstream processes

Use of upstream data associated with production of commodities and raw materials shall follow this hierarchy:

1. Valid facility-specific and product-specific EPDs with impact categories modeled according to TRACI 2.1 for the specific inputs associated with the EPD.

2. Either of the following:

    - valid industry average EPDs with impact categories modeled according to TRACI 2.1 as prescribed in Annex A;
    - freely available public datasets as prescribed in Annex A, including critically reviewed LCA studies that are conformant with ISO 14040/14044 that have been published to the USLCI.

3. Publicly available, critically reviewed LCA studies that are conformant with ISO 14040/14044 that have not been published to the USLCI.




4. Either of the following:

   - commercial (proprietary) inventory data, when process or flow impacts are estimated to be > 1% total; or
   - declared data gap, when process or flow impacts are estimated to be < 1% total, or when no data exists. Any estimations need to be justified. Proxy data shall not be used.

7.1.9.2.2 Uniformity in use of life cycle inventories

Manufacturers who develop product specific EPDs, industry average EPDs, or public datasets that could be used as upstream data for construction aggregates are strongly encouraged to use the public datasets prescribed in Annex A for common upstream energy and materials to improve the consistency and comparability of EPDs developed under this PCR.

7.1.9.2.3 Transparency of life cycle inventories

Background inventory data sources at the flow and database level shall be declared on the EPD.

7.1.9.2.4 Geography and regionalization

The upstream data specified in Annex A are specific to North America. U.S. baseline inventories for electricity shall be regionalized at the balancing authority level (see Annex A for details). Canadian baseline inventories for electricity shall be regionalized at the provincial level.

7.1.9.2.5 Data gaps

Data gap identification shall be performed in accordance with the ACLCA *Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets*[8] for background dataset selection. Data gaps shall be described on the EPD and the following statement should appear:

> *"Data for [list of materials] was not available at time of EPD preparation and may have significant effects on total impacts."*

[8] <https://aclca.org/pcr/>




7.1.9.2.6 Updating prescribed inventory data

The Construction Aggregate PCR Data Subcommittee shall convene at intervals no greater than 12 months to review upstream datasets to determine whether any changes should be made to Annex A. Any resulting revision of Annex A based on this review shall be summarized in the summary of changes section of Annex A and shall include the date of revision. The PCR's date of expiry shall not be affected.

7.1.10 Units

Per ISO 21930:2017 Clause 7.1.10, with the following additions.

As stated in ISO 21930:2017, all EPD values shall be reported using SI units, except that the declared unit is in U.S. Customary. Optionally, EPDs may provide both U.S. imperial and SI units using the following conversion factors from NIST.

Table 7.1
Conversion factors to be used if reporting in IP units (Imperial)

Convert from:	To:	Multiply by:
square meter (m^2)	square foot (ft^2)	1.076391E+01
kilogram (kg)	pound (lb)	2.204622
megajoule (MJ)	British Thermal Unit (BTU)	9.478170E+02
degree Celsius (°C)	degree Fahrenheit (°F)	(°C * 9/5) +32
cubic meter (m^3)	cubic foot (ft^3)	3.531466E+01
meter (m)	foot (ft)	3.281
m^2K/W	ft^2Fhr/Btu	5.6783




Table 7.1

Conversion factors to be used if reporting in IP units (Imperial)

Convert from:	To:	Multiply by:
metric tonne	ton	1.102
Source: NIST: http://physics.nist.gov/Pubs/SP811/appenB9.html; http://www.nist.gov/pml/wmd/metric/ temp.cfm; and http://www.nist.gov/pml/wmd/metric/common-conversion-b.cfm		

7.2 Inventory analysis

7.2.1 Data collection

Per ISO 21930:2017 Clause 7.2.1 shall apply, with the following clarifications.

7.2.1.1 Inputs

- electricity consumption:
  - line power consumption in kWh and zip code or postal code to identify the balancing authority in which the plant is located. Facilities with on-site renewable power generation (solar or wind) shall report gross power consumption *before* any reductions from on-site renewable energy generation. Any offsets or reductions in electricity consumption from on-site renewable energy generation should be reported separately as GHG emission reductions associated with renewable energy purchases in accordance with Section 8.3.
  - If the market-based method for Scope 2 accounting is used to calculate potential GHG emission reductions associated with renewable energy consumption per Section 8.3, whether through on-site renewables or market-based instruments like purchase of RECs, exclusively for the mix production facility, the following data shall be provided:
    - quantity of market-based renewable energy instruments (kWh);
    - supplier or utility-specific emission factors;
    - date of renewable energy generation;

    - documentation that renewable energy instruments are designated for use by the mix production facility and cover the same time period as the other foreground data collected for the EPD;
    - documentation that renewable energy instruments have been retired; and
    - any other documentation necessary to meet the data quality requirements specified in Section 7.1.9.

- On-site fuel consumption by unit process, including the type and volume of fuel consumed:
  - generator fuel consumption:
    - diesel fuel (liters or gallons);
    - liquid biofuel (liters or gallons);
    - compressed natural gas (MMBtu, liters, or gallons); and
    - alternative fuels (energy, mass, or volume).
  - mobile equipment fuel consumption, including loaders, skid-steers, on-site trucks, etc:
    - diesel fuel (liters or gallons);
    - liquid biofuel (liters or gallons);
    - compressed natural gas (MMBtu, liters, or gallons);
    - propane (liters or gallons); and
    - alternative fuels (energy, mass, or volume).
- water usage:
  - washing (liters or gallons); and
  - dust control (liters or gallons).
- explosive usage:
  - ANFO (lb or kg); and
  - emulsion (lb or kg).

- wear parts:
  - manganese steel (lb or kg); and
  - tires.

7.2.1.2 Outputs

- total product sold:
  - unwashed natural aggregate (short tons);
  - washed natural aggregate (short tons);
  - slag aggregate (short tons);
  - reclaimed concrete aggregate (short tons); and
  - reclaimed asphalt pavement (short tons).
- waste and recycling:
  - manganese steel (pounds);
  - tires (pounds); and
  - general waste (short tons).

7.2.2 Calculation procedures

Per ISO 21930:2017.

7.2.3 Allocation situations

Per ISO 21930:2017.

7.2.4 Principles for allocation both allocation situations

Per ISO 21930:2017




7.2.5 Allocation for co-products

7.2.5.1 General

Per ISO 21930:2017.

7.2.5.2 Co-product allocation procedure

Per ISO 21930:2017 with the following clarification.

Allocation may become necessary for production processes in which more than one type of product is generated. Requirements for allocation given in both ISO 21930:2017 Clause 7.2.5 and ISO 14044:2006 Section 4.3.4 shall apply. Where allocation cannot be avoided for co-products, allocation shall be performed on the basis of mass.

In all other cases, including joint co-production processes, where no relevant underlying physical relationships between the products and co-products can be identified, the inventory of the process should be allocated between the products and co-products in a way that reflects the economic value of the co-products when they leave the unit process.

Slag aggregate is a co-product of steel. For each ton of feedstock ore or scrap entering the steelmaking process, about 0.15 tons of slag are created, the rest becoming steel. Significant economic differences exist between these coproducts. Those parts of slag aggregate production that are shared with steel shall be economically allocated (e.g. melting), using the factor given in Annex A. Other operations not shared with steel production (e.g. crushing, washing) shall be directly attributed to slag.

Note on harmonization: The current steel PCR is based on the UL two-part PCR system. In Part B: *Designated Steel Construction Product EPD Requirements*, Section 3.3: *Allocation*, the requirement is for mass-based allocation, but with the stipulation, "Allocation methods deemed more appropriate than on the basis of mass (e.g., economic allocation) may be used but only when justified." In Part A: *Life Cycle Assessment Calculation Rules and Report Requirements*, Section 3.3: *Allocation*, the requirement is that allocation should be based on economic values when the difference in revenue from co-products is not low. It defines a difference in revenues of > 25% as high. Furthermore, a comparative evaluation of the 2018 USGS Mineral Yearbook on Iron and Steel[9] and the 2018 Mineral Yearbook on Slag Iron and Steel[9] determined that the average revenue for slag aggregate is $8.33 for blast




furnace slag and $24.63 for steel furnace slag, compared to $729.20 short ton for steel. This confirms that the historical difference in slag revenue per ton of feedstock is high (> 25%) by a significant margin.

Recycled and recovered materials shall be considered raw materials. Only the materials, water, energy, emissions, and other elemental flows associated with reprocessing, handling, sorting, and transportation from the generating industrial process to their use in the production process shall be considered.

NOTE — See section 7.1.6 for discussion of cutoff boundaries for RCA and unbound asphalt aggregate.

Any allocations before reprocessing shall be allocated to the original product.

Allocation related to transport shall be based on the mass of transported product.

In the case of incineration of wastes for energy production at the primary production site, the combustion emissions shall be allocated to the building product unless the energy is exported.

For transparency, the indicators on the uptake of CO_2 due to carbonation shall be separately reported, where available, in supplemental environmental information ISO 21930 Clauses 7.2.12 and 8.3. See details on carbonation calculation methods in Annex B.

Likewise, the biogenic carbon reporting requirements specific to ISO 21930 Clause 7.2.12 do not apply.

7.2.5.3 Avoiding allocation generally

Per ISO 21930:2017 Clause 7.2.5.3.

7.2.5.4 Allocation by subdivision

Per ISO 21930:2017 Clause 7.2.5.4, with the following clarification:

Water is used for two major purposes in an aggregate operation — aggregate washing and dust control. Impacts from water used for washing shall be applied only to washed products, while impacts from water used for dust control and other processes (including evaporative loss) shall be applied to all products. If water use is not metered, and an estimate is used, this shall be stated in the EPD.




7.2.6 Allocation between product systems (across the system boundary)

Per ISO 21930:2017 Clause 7.2.6

7.2.7 Accounting of biogenic carbon update and emissions during the life cycle

ISO 21930 Clause 7.2.7 does not apply because construction aggregates and other materials covered by this PCR are not sourced from bio-based materials; therefore, biogenic uptake is not relevant to the product category.

7.2.8 Carbonation

Per ISO 21930:2017 Clause 7.2.8, with the following modifications.

For transparency, the indicators on the uptake of CO_2 due to carbonation shall be separately reported, where available, in supplemental environmental information ISO 21930 Clauses 7.2.12 and 8.3. See details on carbonation calculation methods in Annex B.

7.2.9 Accounting of delayed emissions

This section is not applicable to this PCR.

7.2.10 Inventory Indicators describing resource use

Per ISO 21930:2017 Clause 7.2.10.

7.2.11 Greenhouse gas emissions from land use change

Per ISO 21930:2017 Clause 7.2.11.

7.2.12 Additional inventory indicators describing emissions and removal of carbon

Per ISO 21930:2017 Clause 7.2.12, with the following modifications.




For transparency, the indicators on the uptake of CO_2 due to carbonation shall be separately reported, where available, in supplemental environmental information ISO 21930 Clauses 7.2.12 and 8.3. See details on carbonation calculation methods in Annex B.

7.2.13 Inventory indicator describing consumption of freshwater

Per ISO 21930:2017 Clause 7.2.13.

7.2.14 Environmental information describing waste categories and output flows

Per ISO 21930:2017 Clause 7.2.14.

7.3 Impact assessment indicators describing main environmental impacts derived from LCA

Per ISO 21930:2017 Clause 7.3.

8 ADDITIONAL ENVIRONMENTAL INFORMATION

Per ISO 21930:2017 Clause 8, with the following modifications.

Additional information shall only be related to environmental aspects. Information and instructions on product safety unrelated to the environmental performance of the building product shall not be part of a Type III environmental declaration (ISO 14025:2006, ASTM 7.2.3).

8.1 General

Per ISO 21930:2017 Clause 8.1.

8.2 Additional LCA related information not included in preset LCIA indicators

Per ISO 21930:2017 Clause 8.2.




8.3 Additional environmental information not derived from or related to LC

Per ISO 21930:2017 Clause 8.3 with the following modifications.

For GHG emission reductions associated with renewable energy purchases, if renewable energy is purchased through either the use of on-site renewables or market-based instruments such as RECs, PPAs, or other financial instruments, the GHG emission reductions associated with these purchases may be reported as ΔGHG_{RE}. This value shall be calculated as the difference between GHG emissions associated with the location-based and the market-based methods for Scope 2 accounting under the GHG Protocol Corporate Reporting Standard (GHG Protocol, 2015[9]). For example, if the location-based and market-based methods for Scope 2 accounting are 2.0 and 1.5 kg CO_2e/tonne, respectively, ΔGHG_{RE} would be -0.5 kg CO_2e/tonne.

For transparency, the indicators on the uptake of CO_2 due to carbonation shall be separately reported, where available, in supplemental environmental information ISO 21930 Clauses 7.2.12 and 8.3. See details on carbonation calculation methods in Annex B.

8.4 Mandatory additional environmental information

Per ISO 21930:2017 Clause 8.

9 CONTENT OF AN EPD

9.1 General

Per ISO 21930:2017 Clause 9.1.

9.2 Declaration of general information

Per ISO 21930:2017 Clause 9.2, with the following additions:

- description of the product contents shall be presented both by weight and by percent weight of the total;
- declared unit of 1 ton of construction aggregate and optionally 1 metric tonne;

[9] World Resource Generator . (n.d.). Standards. Standards | Greenhouse Gas Protocol. Retrieved September 22, 2022, from <https://ghgprotocol.org/standards>




- product description shall include general information on aggregate category and size; and if applicable the relevant ASTM standard that defines the material;
- aggregate tonnage refers tonnage as sold;
- statement that the EPD is cradle-to-gate;
- data collection period for foreground data (12-month consecutive);
- materials should be identified by the following:
    - source; and
    - local name(s).
- include the following table:




Product Name	
Manufacturer Name and Address	
Program Operator	
General Program instructions and Version Number	
Declaration Number	
Reference PCR and Version Number	
EPD Type and Scope (facility/product/average)	
Defined functional or declared unit	
Product's intended Application and Use	
Product RSL (Reference Service Life)*	
Markets of Applicability	
Date of Issue	
Period of Validity	
Year of reported manufacturer primary data	
LCA Software and Version Number	
LCI Database and Version Number	
LCIA Methodology and Version Number	
Overall Data Quality Assessment Score	
The sub-category PCR review was conducted by:	Industrial Ecology Consultants, Thomas P. Gloria, Ph.D, t.gloria@industrial-ecology.com
This declaration was independently verified in accordance with ISO 14025: 2006. ISO 21930:2017 serves as the core PCR. Sub-category PCR: NSF/ASTM 1126: Construction Aggregates Product Category Rule ☐ Internal ☐ External	
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	
Explanatory material may be obtained from the following:	
*Only applicable where the LCA/EPD includes Module B.	




9.3 Declaration of methodological framework

Per ISO 21930:2017 Clause 9.3, with the following additions and clarifications.

For cradle-to-gate EPDs, use case scenarios beyond A1-A3 are not considered in scope and shall not be reported.

The EPD shall include the following:

- a table or figure summarizing the life cycle stages included in the EPD (see Table 9.1);
- a table outlining the background sources of data used to complete the upstream material LCI data including the date or version number; and
- for industry-wide average EPDs, include the date and source of industry data survey including a list of all companies who participated in the EPD data.

Table 9.1
Life cycle stage modules to be included in the EPD (Source: 21930:2017)

Product stage			Construction process stage		Use stage							End-of-life stage			
Raw material supply	Transport	Manufacturing	Transport	Construction-installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport	Waste processing	Disposal
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
NOTES — X = module declared MND = module not declared															




9.4 Declaration of technical information and scenarios

ISO 21930:2017 Clause 9.4 does not apply to cradle-to-gate EPDs.

9.5 Declaration of environmental indicators derived from LCA

Per ISO 21930:2017 Clause 9.5, with the following additions:

- carbonation impacts shall be reported in a separate table with the note:

  "End-of-life carbonation, as occurring in recycled concrete aggregate, is an area of ongoing study. The following impacts are reported separately to acknowledge the greater uncertainty in the calculation of impacts of carbonation as of now."

- When upstream data (either specified in the PCR or from other sources) are missing values for select impact categories or inventory items that are required to be reported in the EPD, the impact categories or inventory items shall be reported with an asterisk '*' or as an 'x' or '-' and not zero, and be qualified with the footnote:

  "This EPD meets all comparability requirements stated in ISO 14025:2006. However, differences in certain assumptions, data quality, and variability between LCA data sets may still exist. As such, caution should be exercised when evaluating EPDs from different manufacturers or programs, as the EPD results may not be entirely comparable. Any EPD comparison must be carried out at the construction works level per ISO 21930:2017 guidelines. The results of this EPD reflect an average performance by the product and its actual impacts may vary on a case-to-case basis."

9.6 Declaration of additional environmental information

Per ISO 21930:2017 Clause 9.6, with the following additions.

The following references shall be provided at a minimum in the EPD:

- ISO 21930:2017, *Sustainability in Building Construction — Environmental Declaration of Building Products; and*
- *NSF PCR for Construction Aggregates (2022).*




Specific life cycle inventory datasets shall be declared for any modeled flows or processes not included in Annex A.

The reference Annex A version shall be reported.

The most recent version of Annex A as of the date of EPD publishing shall be used.

If carbonation is included in the EPD, the method of calculation shall be reported, as well as all reporting requirements given in Annex B.

10 PROJECT REPORT

Per ISO 21930:2017 Clause 10, with the following addition.

EPDs for construction aggregates that are developed using a verified software tool do not need an individual project report for each EPD. Instead, the underlying project report for the software tool may serve as the project report for the EPD.

11 VERIFICATION AND VALIDITY OF AN EPD

Per ISO 21930:2017 Clause 11, with the following additions:

EPD calculations completed by software systems are permitted provided the software has been verified in a process similar to that of the verification of an EPD. The process used to verify the software calculations should be publicly accessible and referenced from the EPD. When a product specific EPD is aligned with an industry-wide average EPD, the following additional item is required.

In order to evaluate the consistency of results between product specific EPDs and industry-wide average EPDs the same LCA background data set and characterization model shall be used to create the EPD; EPDs shall be recalculated when any of the following conditions apply:

- an EPD shall be recalculated when changes to manufacturing practices are reasonably expected to result in a significant change to the EPD results;




- an EPD shall be recalculated when its period of validity is complete or when updates to the PCR result in significant changes to the EPD results; and
- significant changes are an increase or decrease of GWP 100, AP, EP or POCP by > 5% of previously reported result.

12 REFERENCES

The development of this PCR included consideration and reference to the following PCRs:

Part B for Steel Construction Product EPD Requirements, Second Edition, August 2020

Product Category Rules for Asphalt Mixtures, version 2.0, April 2022

Product Category Rules for Environmental Product Declarations PCR for Concrete, February 2019

ASTM Standards:

C330/C330M-14, *Standard Specification for Lightweight Aggregates for Structural Concrete*

C331/C331M-14, *Standard Specification for Lightweight Aggregates for Concrete Masonry Units*

C332-09, *Standard Specification for Lightweight Aggregates for Insulating Concrete*

ISO Standards:

ISO 6707-1, *Buildings and Civil Engineering Works – Vocabulary – Part 1: General Terms*

ISO 14021/AMD1, *Environmental Labels and Declarations – Self-declared Environmental Claims (Type II Environmental Labeling)*

ISO 14050, *Environmental Management – Vocabulary*

ISO 15686-1, *Buildings and Constructed Assets – Service life planning – Part 1: General Principles and Framework*

Other References:

ACLCA *Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets*




EN 15804, *Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products*, January 2012




APPENDIX A: DATA SOURCE AND QUALITY

Annex A Revision Date: September 1, 2022

When selecting datasets for an EPD for construction aggregates, it is important the datasets support the generation of high-quality, accurate, comparable, and transparent EPDs as per the ACLCA *Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets*. The following goals shall drive dataset selection:

- use of datasets evaluated and supported by the ACLCA *Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets;*
- prescription of data sets;
- use of publicly available datasets;
- data quality evaluation using the Enhanced Pedigree Matrix;
- avoiding use of proxy datasets; and
- justification of any deviations from the above.

As specified in Section 7.1.9.2.6, the Construction Aggregate PCR Data Subcommittee will meet at intervals no greater than 12 months to evaluate and update the information in Annex A.

Table A.1
Prescribed data flow for construction aggregates

Date type	Background inventory	Reference / comment
electricity – U.S. grid	U.S. DOE NETL U.S. electricity baseline	ACLCA Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets Recommended <www.lcacommons.gov/lca-collaboration/Federal_LCA_Commons/US_electricity_baseline/datasets>
electricity – Canadian grid	Ecoinvent 3.8	
electricity – onsite solar	not evaluated or incomplete	

Table A.1
Prescribed data flow for construction aggregates

Date type	Background inventory	Reference / comment
electricity – onsite wind	not evaluated or incomplete	
propane fuel in engines	U.S. EPA-USLCI-GREET [a] Dataset Operation of liquefied petroleum gas equipment, industry average: > 56 kW and < 560 kW (V 00.00.030)	ACLCA Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets Recommended <www.lcacommons.gov/lca-collaboration/US_Environmental_Protection_Agency/Heavy_equipment_operation/dataset/PROCESS/12ecfd99-a5bd-32bd-8d38-99307d8ef37a>
	U.S. EPA-USLCI-GREET [a] Dataset Diesel, combusted in industrial equipment (V 00.00.003)	ACLCA Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets Recommended <www.lcacommons.gov/lca-collaboration/Federal_Highway_Administration/mtu_pavement/dataset/PROCESS/d6ad7035-5498-3237-8abd-50e93b1eef89>
gasoline fuel in engines	U.S. EPA-USLCI-GREET [a] Dataset Gasoline, combusted in equipment	ACLCA Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets Recommended <www.lcacommons.gov/lca-collaboration/National_Renewable_Energy_Laboratory/USLCI_Database/dataset/PROCESS/d3e13675-1455-375f-a557-bb8234de75ff>
renewable diesel fuel in engines		GREET
biodiesel fuel in engines		Production inventory exists, but need combustion data




Table A.1
Prescribed data flow for construction aggregates

Date type	Background inventory	Reference / comment
compressed natural gas fuel in engines	U.S. EPA-USLCI-GREET [a] Dataset Operation of compressed natural gas equipment; industry average; > 56 kW and < 560 kW (V 00.00.031)	ACLCA Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets recommended <www.lcacommons.gov/lca-collaboration/US_Environmental_Protection_Agency/Heavy_equipment_operation/dataset/PROCESS/6e687c52-4256-374e-b56f-6520c390a00e>
recycled fuel oil fuel in engines	U.S. EPA-USLCI-GREET [a] Dataset recycled fuel oil (V 00.00.010)	Inventory developed for asphalt PCR, published publicly on FLCAC <www.lcacommons.gov/lca-collaboration/Federal_Highway_Administration/mtu_pavement/dataset/PROCESS/9d8647f1-1cf0-41e9-9954-ab99bf710150>
rail transportation	NETL/USLCI dataset Transport, train, diesel powered (V 00.00.003)	ACLCA Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets recommended <www.lcacommons.gov/lca-collaboration/Federal_Highway_Administration/mtu_pavement/dataset/FLOW/73c7494d-4e93-3769-896b-8bb82f0dfccc>
truck transportation	NETL/USLCI dataset Transportation, combination truck, diesel powered (V 00.00.003)	ACLCA Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets Recommended <www.lcacommons.gov/lca-collaboration/National_Renewable_Energy_Laboratory/USLCI_Database_Public/dataset/PROCESS/34156f3c-28ef-33db-9ad0-6293a2aa0d52>




Table A.1
Prescribed data flow for construction aggregates

Date type	Background inventory	Reference / comment
barge transportation	NETL/USLCI dataset Transport, barge, diesel powered (V 00.00.003)	ACLCA Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets Recommended <www.lcacommons.gov/lca-collaboration/Federal_Highway_Administration/mtu_pavement/dataset/PROCESS/c2300fc3-5496-3d12-9135-67dc0ef740c9>
ocean transportation	NETL/USLCI dataset Transport, ocean freighter, diesel powered (V 00.00.003)	ACLCA Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets Recommended <www.lcacommons.gov/lca-collaboration/National_Renewable_Energy_Laboratory/USLCI_Database_Public/dataset/PROCESS/da0f5501-f4ab-32d1-80b7-b70d143608f6>
tires		data gap
crusher wear parts (manganese steel)		factors given below
flocculant chemicals		data gap
ANFO and emulsion explosives		factors given below
[a] Federal LCA Commons <www.lcacommons.gov/lca-collaboration/Federal_LCA_Commons/US_electricity_baseline/datasets>		




Manganese

Source data: Shahjadi Hisan Farjana, Nazmul Huda, M.A. Parvez Mahmud, Candace Lang, A global life cycle assessment of manganese mining processes based on EcoInvent database, Science of The Total Environment 688, 1102–1111 (2019).

Declared unit: 1 kg refined manganese

TRACI 2.1 Indicator	Unit	Value
acidification	kg SO_2 eq	0.34
eutrophication	kg N eq	0.088
global warming	kg CO_2 eq	4.53
ozone depletion	kg CFC-11 eq	4.47E-8
smog formation	kg O_3 eq	0.023

Manganese steel

Source Data: Manganese data cited above, and industry average “Environmental Product Declaration for Fabricated Steel Plate, American Institute of Steel Construction” performed by Sphera, 2021, https://www.aisc.org/globalassets/why-steel/epd-aisc-plate-2021.pdf

Declared unit: 1 lb of 15% Mn cast steel by weight




TRACI 2.1 Indicator	Unit	Value
acidification	kg SO_2 eq	0.0546
eutrophication	kg N eq	1.85E-3
global warming	kg CO_2 eq	2.34
ozone depletion	kg CFC-11 eq	9.57E-9
smog formation	kg O_3 eq	8.83E-3

Flocculant

There are many types of flocculant in commercial use, based on a variety of chemistries. Background data is not available for proprietary flocculant chemicals. This is a significant data gap in this analysis. Based on the data collected for this study we found facilities use on average 0.041 lb (dry) or 0.053 gal (wet) flocculant per short ton of aggregate produced.

TRACI 2.1 Indicator	Unit	Value
acidification	kg SO_2 eq	unknown
eutrophication	kg N eq	unknown
global warming	kg CO_2 eq	unknown
ozone depletion	kg CFC-11 eq	unknown
smog formation	kg O_3 eq	unknown




Explosives

Source Data: Dyno Nobel Asia Pacific Pty Limited. (2016, May). *ANFO (bagged) technical information - dyno nobel*. ANFO Technical Information. Retrieved August 4, 2022, from https://www.dynonobel.com/apac/~/media/Files/Dyno/ResourceHub/Technical%20Information/Asia%20Pacific/PackagedExplosives/ANFO%20Bagged.pdf.

TRACI 2.1 indicator	Unit	Value
acidification	kg SO_2 eq	0.09060
eutrophication	kg N eq	0.04610
global warming	kg CO_2 eq	12.7606
ozone depletion	kg CFC-11 eq	5.9629E-7
smog formation	kg O_3 eq	2.1728

The revenue of slag aggregate per short ton of feedstock ore or scrap was $4.38,[10] while steel was $629.83[11] (revenues averaged from 2017-2021). Or, stated in terms of steel produced: For each short ton of steel produced, the revenue is $740.97, and an average of 0.18 tons of slag is generated for a revenue of $4.68. This results in a relative revenue of < 1%. As a result, the economic allocation factor for slag as a coproduct for steel shall be 0.01.

Electrical dataset instructions

U.S. electrical grid will use NETL data and an unweighted average of all of the balancing authorities represented in the zip code the aggregate is produced in. See an example(s) below:

[10] <https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-iron-steel-slag.pdf>

[11] <https://tradingeconomics.com/commodity/steel>

<u>U.S. electricity calculation protocol:</u>

1. Electricity data in the DOE NETL is regionalized at the country (U.S. average), FERC region, and balancing authority (BA) levels. BA-level electricity data shall be used according to the specifications in Annex 1 and the following algorithm:

    a. Identify a facility's available balancing authorities using the facility zip code and the U.S. Energy Atlas[12] zip code-to-BA mapping.
    b. If multiple BAs are mapped to a zip code, electricity impacts shall be estimated using the unweighted arithmetic mean of each TRACI 2.1 indicator for the set of BAs mapped to the given zip code. For example, if three balancing authorities (BA1, BA2, and BA3) are mapped to a single zip code (C), then the GHG impacts for 1 MW of electricity for zip code C will be calculated as:

$$GHG(C) = \frac{GHG(BA1) + GHG(BA2) + GHG(BA3)}{3}$$

<u>Canadian electricity calculation protocol:</u>

2. Canadian electrical grid will use Province-Level Ecoinvent 3.8 data from the province the aggregate is produced in.

Summary of Changes

None.

[12] NERC Regions | NERC Regions | U.S. Energy Atlas (eia.gov) <https://atlas.eia.gov/datasets/eia::nerc-regions/explore?location=36.698572%2C-98.159403%2C4.34>

APPENDIX B: CARBONATION

Concrete, at end-of-life, is commonly reprocessed through crushing for reuse as a secondary product known as recycled concrete aggregate (RCA). The process of crushing concrete demolition waste exposes additional surface area to atmospheric carbon dioxide, which can accelerate carbonation reactions on the surface of the RCA. Carbonation is a well-known, well-documented, inherent quality of concrete and RCA. Carbonation represents sequestration of carbon dioxide from the atmosphere via mineralization through reactions with calcium oxide, calcium hydroxide or calcium-silicate hydrates. ISO 21930:2017 Clause 7.2.8 requires that environmental impacts considered during the production, use and end-of-life stages shall include carbonation.

Per ISO 21930 Clause 7.2.8 Carbonation, carbonation is an inherent property of concrete, for details see ISO 21930.

This PCR recognizes that while the quantification of carbonation is complex and influenced by several variables, approximate and empirical models can form the basis of calculation. There is a growing body of literature surrounding carbonation during end-of-life processing of concrete; this PCR update attempts to advance the state of the PCR by providing a conservative approach to account for carbonation while recognizing that future updates will provide opportunities for iterative refinements to this methodology as the science evolves.

This PCR update proposes three approaches of increasing complexity to account for carbonation in RCA.

The application of these methods in accounting for carbonation in RCA is limited to RCA exposed to atmospheric CO_2. Per allocation rules in Section 7.5, only elemental flows associated with reprocessing, handling, sorting, and transportation from the generating industrial process to their use in the production process need to be considered. While a growing number of innovations in this space either currently exist or are under development, technologies that involve inputs beyond RCA and atmospheric carbon dioxide are beyond the scope of this PCR and thus it is recommended that LCA be conducted to more accurately account for environmental benefits and impacts including carbonation for these materials.

The primary variables impacting carbon uptake of stockpiled RCA include RCA aggregate size, stockpile geometry, and how long the RCA is held in a stockpile (AzariJafari, 2021[13]).

[13] Hessam AzariJafari, Fengdi Guo, Jeremy Gregory, Randolph Kirchain, Carbon uptake of concrete in the U.S. pavement network, Resources, Conservation and Recycling, Volume 167, 2021




The following three methods for quantification of carbonation associated with RCA may be used:

B.1 Method 1 – Apply a singular, conservative carbonation coefficient of -0.35 kgCO_2e / short ton of RCA, regardless of site conditions

The carbonation coefficient of -0.35 kgCO_2e/short ton (note factor converted from concrete yardage reference Table B.1 which follows) was derived from evaluating numerous scenarios through the Global Cement and Concrete Association Industry EPD tool for Cement and Concrete v3.1 (LCA Model, North American Version) (Dauriat, A. et. al.[14]). The default carbonation coefficient proposed for use is the most conservative carbonation coefficient provided through the scenarios evaluated. The scenarios evaluated impact of two variables on the rate of projected carbonation: concrete strength and duration RCA is held in stockpile.

Concrete mix designs were based on Benchmark Ready-Mix Designs as detailed in the July 2022 study commissioned by the National Ready-Mix Concrete Association (NRMCA) “A Cradle to Gate Life Cycle Assessment of Ready Mixed Concrete Manufactured by NRMCA Members – Version 3.2”. The concrete strength classes evaluated included 2500, 3000, 4000 and 5000 psi. A recycling rate of 100% was assumed in the GCCA model. It was also assumed that the stockpile was exposed to precipitation.

The carbonation coefficients derived from the GCCA EPD Tool (v3.1) as influenced by mix design, concrete strength and RCA stockpile duration are illustrated in Table B.1. This PCR proposes the use of the most conservative carbonation coefficient derived from the iterative runs of the GCCA model and is highlighted in Table B.1 below.

[14] Dauriat, A., A. Coulon, J. Bitar, X. Liao and C. Delerce-Maurice. (2021) GCCA Industry EPD Tool for Cement and Concrete (v3.1) LCA Model, International Version. Retrieved from https://www.concrete-epd-tool.org/



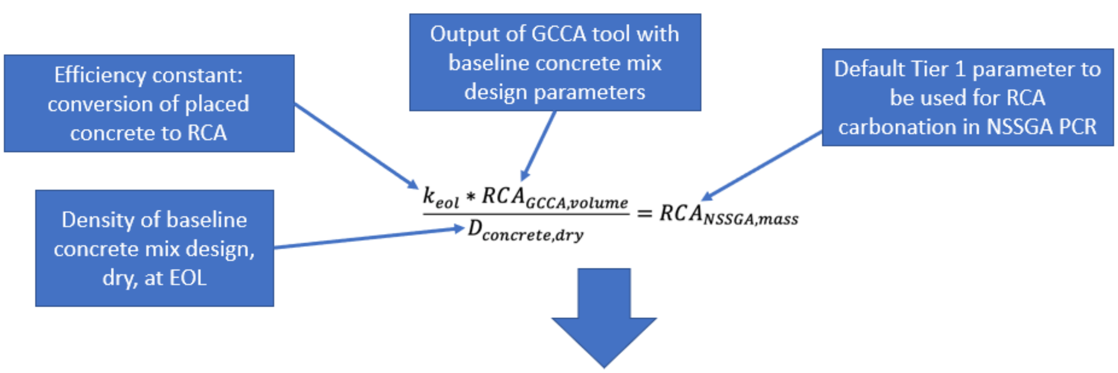

Table B.1

Impact of mix design, concrete strength and RCA stockpile duration on carbonation coefficient from the GCCA Industry EPD Tool for Cement and Concrete v3.1.

GCCA Tool End of Life Ready Mix C3 waste processing
Table B1- NRMCA U.S. National Benchmark Mix Designs (per cubic yard)

		Resulting recarbonation (CO2 eq./ yd³ of ready-mix concrete)											
		100% Portland Cement Mixes								100% Portland Limestone Mixes			
		Table (page 67 of NRMCA Study)				Table (pages 48 & 49 of NRMCA Study)							
Compressive Strength	psi	2500	3000	4000	5000	2500	3000	4000	5000	2500	3000	4000	5000
RCA Stockpile Duration	months												
	0.25	1.05	**0.69**	0.84	1.01	1.26	0.85	1.07	1.34	1.14	0.77	0.97	1.21
	1	2.09	1.38	1.67	2.02	2.5	1.69	2.14	2.67	2.26	1.53	1.93	2.41
	3	3.58	2.38	2.87	3.48	4.3	2.91	3.69	4.59	3.89	2.63	3.33	4.16
	6	5.03	3.35	4.04	4.9	6.03	4.09	5.19	6.47	5.45	3.7	4.69	5.85
	12	7.03	4.71	5.68	6.89	8.43	5.75	7.29	9.09	7.63	5.2	6.59	8.22
	24	9.79	6.6	7.96	9.65	11.74	8.06	10.21	12.73	10.62	7.29	9.23	11.51

The conversion of the carbonation coefficient per unit mass (short tons) was derived from the following calculation:



$$\frac{k_{eol} * RCA_{GCCA,volume}}{D_{concrete,dry}} = RCA_{NSSGA,mass}$$

$$\frac{0.9 * \left(0.69 \, {}^{kg\, CO_2e}/_{yd^3}\right)}{1.7905 \, {}^{shtn}/_{yd^3}} = 0.3468 \frac{kg\, CO_2e}{shtn}$$




B.2 Method 2 – Calculate carbonation coefficient based on a limited set of unique conditions present at the RCA producer facility using the current version of the free, open source, MIT Whole Lifecycle Carbon Uptake Tool

Only the portion of the tool related to end-of-life shall be used to estimate end-of-life carbon uptake**.** Site specific input parameters are: stockpile geometry (diameter at top of stockpile, diameter at bottom of stockpile and stockpile height, slope and whether is it sheltered from the rain), RCA aggregate size, stockpile duration and mass of RCA. Tool and documentation can be accessed at: <https://cshub.mit.edu/whole-life-cycle-carbon-uptake-tool>.

Requirements

- document input variables used to populate the tool: stockpile top diameter, stockpile bottom diameter, stockpile height, RCA aggregate size, stockpile duration and mass of RCA.
    - if a producer has a stockpile that does not conform to the basic stockpile requirements of the MIT method, this method cannot be used.
- provide documentation to justify input variables used;
- use the most current version of the MIT Tool at the time of calculation and document the version of the MIT Tool used in the EPD;
- use the NRMCA benchmark mix of 3000 psi. See National Ready-Mix Concrete Association (NRMCA) “A Cradle to Gate Life Cycle Assessment of Ready Mixed Concrete Manufactured by NRMCA Members – Version 3.2”.

B.3 Method 3 – Quantify average carbonation rate in RCA stockpile through field sampling and lab tests for carbonation

Sampling methodology

This PCR recognizes that RCA stockpiles will be heterogeneous and dynamic in nature as additions to the stockpile will be made over time, and that the source of recycled/demolished concrete will vary. As such, a consistent approach to sampling methodology is critical.

The practitioner shall establish the baseline carbon content present in RCA at time of receipt of RCA at the receiving facility.

Stockpile sampling shall be representative, and the practitioner *shall describe the methods utilized.* An example method is provided below:

- **sampling to quantify carbon sequestered** in RCA after receipt at producer facility:
  - **stockpile heterogeneity**: Ensure sampling methodology accounts for heterogeneity of carbon uptake based on spatial location within the stockpile (according to ASTM D75).
  - **sample preservation**: Describe the sample preservation method employed to ensure that samples shall be immediately preserved after collection in a manner that will stop additional carbonation reactions from taking place after sample collection.
  - **minimum sample size**: A minimum sample size of 30 grab samples per sample event stockpile
  - **document dates of stockpile additions**: Document quantity and date of all stockpile additions
  - **document dates of sample collection**

- **lab methodology**: The methodology developed by D’Avela et al (2016)[15] or Thermogravimetric Analysis in accordance with ASTM E1131 and ISO 11358 to quantify total carbon mineralized shall be followed.
- **calculation**: coefficient for carbon sequestered through the exposure of RCA to atmospheric carbon dioxide shall be based on:

  $$\text{Carbonation}=\bar{X}\_(\text{Baseline Carbon in RCA})/\gamma-\bar{X}\_(\text{Mineralized Carbon Samples})/\gamma$$

  baseline carbon in RCA: mineralized carbon content in concrete waste at the point of receipt at the concrete processing facility, prior to any processing occurring. This is quantified through the methodology developed by D’Avela et al (2016) or Thermogravimetric Analysis as detailed above and calculated as the average of the samples taken during a single sampling event.

  carbonation samples: mineralized carbon content in the RCA after processing and stockpiling. This is quantified through the methodology developed by D’Avela et al (2016) or Thermogravimetric Analysis as detailed above and calculated as the average of the RCA samples taken during a single sampling event.

[15] Bao, Jiangyin & D'Avela, Canan & Croxen III, Fred & Downs, Robert & Fickett, Steve & Rodrigues, Hugh & Rothstein, David & Thompson, Jason. (2016). Preliminary Method to Determine CO2 Sequestration in Cementitious Units. TMS eJournal. 34. 19.




APPENDIX C: TECHNICAL REVIEW COMMITTEE

The following individuals participated in the review committee from September 2021 through May 2023.

Manufacturers

Matthew Hinck, CalPortland – Committee Chairperson

John Yzenas, EDW C Levy Co

Kyle Brashear, Martin Marietta

David Farris, Rogers Group, Inc

Robin Graves, CEMEX

Greg McKinnon, Stoneway Concrete

Brian Rice, Lehigh Hanson

Matt Dalkie, LaFarge Canada

Kevin Vaughan, Vulcan Materials Company

Ron Sines, CRH Americas

Juan Gonzalez, Central Concrete Supply

Trade Associations

Hadi Rashidi, National Stone Sand and Gravel Association

Katie Poss,National Ready Mix Concrete Association

Users

Shawn Kalyn, Votorantim / St Marys Cement LLC

Milena Rangelov, Federal Highway Administration

Elaine Lai, Skanska

Laurel McEwen, Climate Earth

Lianna Miller, WAP Sustainability

James Salazar, ATHENA Sustainable Materials Institute

Ben Ciavola, WAP Sustainability

Academia

Doug Hooton, University of Toronto

Erol Tutumluer, University of Illinois – Urbana-Champaign




LCA Expertise

Jack Geibig, Ecoform, LLC

NSF International

Andrea Burr

THE HOPE OF MANKIND rests in the ability of man to define and seek out the environment which will permit him to live with fellow creatures of the earth, in health, in peace, and in mutual respect.