ENVIRONMENTAL PRODUCT DECLARATION

Environmental Product Declaration for ready mix concrete products produced by Holcim Nicaragua at their KM12 facility in Managua, Nicaragua.

HOLCIM

ADMINISTRATIVE INFORMATION

International Certified Environmental Product Declaration

Declared Product:	This Environmental Product Declaration (EPD) covers concrete products produced by Holcim Nicaragua. Declared unit: 1 m3 of concrete
Declaration Owner:	Holcim Nicaragua
	km 34.5 Carretera Nueva a Leon-Nagarote-Leon
	Nagarote, Nicaragua
	www.holcim.com.ni
Program Operator:	Labeling Sustainability
	Address, 11670 W Sunset Blvd.
	City, State, Los Angeles, CA
	www.labelingsustainability.com/
Product Category Rule:	Core PCR: ISO 21930:2017 Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services SubPCR: NSF International (March 2020). Product Category Rul (PCR) for Environmental Product Declarations (EPD) PCR for Concrete, v2.1
	Sub PCR Program Operator: NSF International
	Sub-category PCR review was conducted by: Thomas P. Gloria, Ph. D. of Industrial Ecology Consultants: 35 Bracebridge, Rd., Newton, MA 02459-1728, t.gloria@industrial-ecology.com. Dr. Michael Overcash of Environmental Clarity: 2908 Chipmunk Lane, Raleigh, NC 27607-3117, mrovercash@earthlink.net. Mr. Bill Stough of Sustainable Research Group: PO Box 1684, Grand Rapids, MI 49501-1684, bstough@sustainableresearchgroup.com. Mr. Jack Geilbig, EcoForm: 2624 Abelia Way, Suite 611, Knoxville, TN 37931, jgeilbig@ecoform.com.
Independent LCA Reviewer and EPD Verifier:	This EPD was independently verified in accordance with ISO 14025 and ISO 21930. The life cycle assessment was independently reviewed in accordance ISO 14044 and the referenced PCR.
	Independent verification of the declaration, according to ISO 14025:2006
	Internal ☐ ; External X
	Third Party Verifier
	Geoffrey Guest, Certified 3rd Party Verifier under the International EPD Program (www.environdec.com), CSA Group (www.csaregistries.ca)
Date of Issue:	04 August 2023
Period of Validity:	5 years; valid until 03 August 2028
EPD Number:	56072280-efe5-44c4-9fd3-3d5053a031c6

TABLE OF CONTENTS

COMPANY DESCRIPTION

Holcim (Nicaragua) SA was born in 1997 as a result of the union of a group of distinguished Nicaraguan investors and Holcim Ltd. The Company is part of the Holcim Group, formerly the LafargeHolcim Group, created in July 2015, as a result of the merger of Holcim and Lafarge.

Holcim Nicaragua is a member of the international group of the same name, leader in the construction materials industry, operating in Nicaragua for 23 years, producing cement, concrete, aggregates and solutions for the construction market. The company offer different types of cement solutions with special qualities: Holcim Fuerte EcoPlanet, Holcim Industrial and Holcim Superbloque, our leading Fuerte EcoPlanet cement has ECO Labels that guarantee a cement with 35% less CO2 emissions per ton.

Currently, Holcim (Nicaragua) SA, with a cement production capacity of more than 400,000 tons per year, occupies a preferential place among consumers, an achievement obtained from product quality, technical support and excellence in customer service. The company has a cement grinding plant in Nagarote, a fixed concrete plant in Managua, mobile concrete equipment in Chinandega, and an aggregates plant in Cofradía. It have Disensa, the largest hardware network in the country, generating value for the owners of more than 78 points of sale and their clients with a presence in 14 departments and two autonomous regions of Nicaragua.

STUDY GOAL

The intended application of this life cycle assessment (LCA) is to comply with the procedures for creating a Type III environmental product declaration (EPD) and publish the EPD for public review on the website, http://labelingsustainability.com/ . This level of study is in accordance with EPD Product Category Rule (PCR) for Ready Mix Concrete published by NSF International (2019) and is a sub-PCR of International Standards Organization (ISO) 21930:2017 Sustainability in buildings and civil works - Core rules for EPDs of construction products and services; International Standards Organization (ISO) 14025:2006 Environmental labels and declarations, Type III environmental declarations-Principles and procedures; ISO 14044:2006 Environmental management, Life cycle assessment- Requirements and guidelines; and ISO 14040:2006 Environmental management, Life cycle assessment-Principles and framework. The performance of this study and its subsequent publishing is in alignment with the business-to-business (B2B) communication requirements for the environmental assessment of building products. The study does not intend to support comparative assertions and is intended to be disclosed to the public.

This project report was commissioned to differentiate Holcim Nicaragua from their competition for the following reasons: generate an advantage for the organization; offer customers information to help them make informed product decisions; improve the environmental performance of Holcim Nicaragua by continuously measuring, controlling and reducing the environmental impacts of their products; help project facilitators working on Leadership in Energy and Environmental Design (LEED) projects achieve their credit goal; and to strengthen Holcim Nicaragua's license to operate in the community. The intended audience for this LCA report is Holcim Nicaragua's employees, their suppliers, project specifiers of their products, architects, and engineers. The EPD report is also available for policy makers, government officials interested in sustainability, academic professors, and LCA professionals. This LCA report does not include product comparisons from other facilities.

DESCRIPTION OF PRODUCT AND SCOPE

This EPD reports on 62 concrete mixes manufactured at the KM12 Holcim Nicaragua concrete facility in Managua, Nicaragua.

This LCA assumes the impacts from products manufactured in accordance with the standards outlined in this report. This LCA is a cradle-to-gate study, and therefore, stages extending beyond the plant gate are not included in this LCA. Excluded stages include transportation of the manufactured material to the construction site; on-site construction processes and components; building (infrastructure) use and maintenance; and "end-of-life" effects.

READY MIX CONCRETE DESIGN SUMMARY

The following tables provide a list of the cement products considered in this EPD along with key performance parameters.

Mix Designs: 0 to 15MPa

Table 1: **Declared products with Mix designs: 0 to 15MPa considered in this environmental product declaration**

Mix#	Unique name/ID	Short description	Product type	28 day strength, MPa	H2O to cement ratio
1	F05-H44B28	1 MPa 28d strength ready mix concrete.	Ready Mix	1.0	3.9062500
2	R03-H00B28 RF	3 MPa 28d strength ready mix concrete.	Ready Mix	3.0	1.3793103
3	M36-L68D28	3.6 MPa 28d strength ready mix concrete.	Ready Mix	3.6	0.7454545
4	M36-L68D14	3.6 MPa 28d strength ready mix concrete.	Ready Mix	3.6	0.6307692
5	M36-L68D03	3.9 MPa 28d strength ready mix concrete.	Ready Mix	3.9	0.5555556
6	M39-L68D14	3.9 MPa 28d strength ready mix concrete.	Ready Mix	3.9	0.6507937
7	M39-L68D03	3.9 MPa 28d strength ready mix concrete.	Ready Mix	3.9	0.5540541
8	M40-M68D14	4 MPa 28d strength ready mix concrete.	Ready Mix	4.0	0.9111111
9	M40-L68D14	4 MPa 28d strength ready mix concrete.	Ready Mix	4.0	0.6612903
10	R04-H00B28 RF	4 MPa 28d strength ready mix concrete.	Ready Mix	4.0	0.5694444
11	M42-L68D28	4.2 MPa 28d strength ready mix concrete.	Ready Mix	4.2	0.6153846
12	M42-L68D07	4.2 MPa 28d strength ready mix concrete.	Ready Mix	4.2	0.5555556
13	M42-L68D03	4.2 MPa 28d strength ready mix concrete.	Ready Mix	4.2	0.5125000

14	M45-L67D28	4.5 MPa 28d strength ready mix concrete.	Ready Mix	4.5	0.5671642
15	M45-L68D03	4.5 MPa 28d strength ready mix concrete.	Ready Mix	4.5	0.4880952
16	M48-L68D28	4.8 MPa 28d strength ready mix concrete.	Ready Mix	4.8	0.5416667
17	M48-L68D03	4.8 MPa 28d strength ready mix concrete.	Ready Mix	4.8	0.4659091
18	R05-H00B28 RF	5 MPa 28d strength ready mix concrete.	Ready Mix	5.0	0.5942029
19	F07-H44B28	7 MPa 28d strength ready mix concrete.	Ready Mix	7.0	1.0000000
20	F10-L46D28	10.5 MPa 28d strength ready mix concrete.	Ready Mix	10.5	0.7540985
21	F10-M44B28	10.5 MPa 28d strength ready mix concrete.	Ready Mix	10.5	0.8196078
22	A10-L46D07	10.5 MPa 28d strength ready mix concrete.	Ready Mix	10.5	0.6197925
23	A10-H44B07	10.5 MPa 28d strength ready mix concrete.	Ready Mix	10.5	0.6904140
24	A10-M44B03	10.5 MPa 28d strength ready mix concrete.	Ready Mix	10.5	0.5887324
25	F14-L46D28	14 MPa 28d strength ready mix concrete.	Ready Mix	14.0	0.7322834
26	F14-M44B28	14 MPa 28d strength ready mix concrete.	Ready Mix	14.0	0.7962264
27	A14-H46B14	14 MPa 28d strength ready mix concrete.	Ready Mix	14.0	0.6697285
28	A14-H44B07	14 MPa 28d strength ready mix concrete.	Ready Mix	14.0	0.6746872
29	A14-M44B03	14 MPa 28d strength ready mix concrete.	Ready Mix	14.0	0.5780822

Mix Designs: 15 to 20 MPa

Table 2: **Declared products with Mix designs: 15 to 20MPa considered in this environmental product declaration**

Mix#	Unique name/ID	Short description	Product type	28 day strength, MPa	H2O to cement ratio
30	F18-L46D28	18 MPa 28d strength ready mix concrete.	Ready Mix	18	0.7121213
31	F18-H46B28	18 MPa 28d strength ready mix concrete.	Ready Mix	18	0.7121211
32	A18-L44D07	18 MPa 28d strength ready mix concrete.	Ready Mix	18	0.6504551
33	A18-L46D03	18 MPa 28d strength ready mix concrete.	Ready Mix	18	0.5086333
34	A18-H44B03	18 MPa 28d strength ready mix concrete.	Ready Mix	18	0.5748744

Mix Designs: 21 to 25 MPa

Table 3: **Declared products with Mix designs: 21 to 25MPa considered in this environmental product declaration**

Mix#	Unique name/ID	Short description	Product type	28 day strength, MPa	H2O to cement ratio
35	F21-L46D28	21 MPa 28d strength ready mix concrete.	Ready Mix	21	0.6785713
36	F21-H46B28	21 MPa 28d strength ready mix concrete.	Ready Mix	21	0.6785715
37	A21-L44D07	21 MPa 28d strength ready mix concrete.	Ready Mix	21	0.6260209
38	A21-L46D03	21 MPa 28d strength ready mix concrete.	Ready Mix	21	0.4927953
39	A21-H44B03	21 MPa 28d strength ready mix concrete.	Ready Mix	21	0.5561943
40	E21-M46B28 Espec	21 MPa 28d strength ready mix concrete.	Ready Mix	21	0.4065934
41	F24-L46D28	24 MPa 28d strength ready mix concrete.	Ready Mix	24	0.6400000
42	F24-H46B28	24 MPa 28d strength ready mix concrete.	Ready Mix	24	0.6400000
43	A24-M46B07	24 MPa 28d strength ready mix concrete.	Ready Mix	24	0.5485714
44	A24-M46B03	24 MPa 28d strength ready mix concrete.	Ready Mix	24	0.4800000

Mix Designs: 26 to 30 MPa

Table 4: **Declared products with Mix designs: 26 to 30 MPa considered in this environmental product declaration**

Mix#	Unique name/ID	Short description	Product type	28 day strength, MPa	H2O to cement ratio
45	F28-L46D28	28 MPa 28d strength ready mix concrete.	Ready Mix	28	0.6158730
46	F28-H46B28	28 MPa 28d strength ready mix concrete.	Ready Mix	28	0.6158730
47	A28-M46B07	28 MPa 28d strength ready mix concrete.	Ready Mix	28	0.5315068
48	A28-M46B03	28 MPa 28d strength ready mix concrete.	Ready Mix	28	0.4674699
49	X28-M46B28 Espec	28 MPa 28d strength ready mix concrete.	Ready Mix	28	0.3737374
50	CAD700-H44B28	28 MPa 28d strength ready mix concrete.	Ready Mix	28	0.4035088

Mix Designs: 31 to 35 MPa

Table 5: **Declared products with Mix designs: 31 to 35 MPa considered in this environmental product declaration**

Mix#	Unique name/ID	Short description	Product type	28 day strength, MPa	H2O to cement ratio
51	F32-L46D28	32 MPa 28d strength ready mix concrete.	Ready Mix	32	0.5939393
52	F32-H46B28	32 MPa 28d strength ready mix concrete.	Ready Mix	32	0.5939395
53	A32-L44D07	32 MPa 28d strength ready mix concrete.	Ready Mix	32	0.5478846
54	A32-M46B03	32 MPa 28d strength ready mix concrete.	Ready Mix	32	0.4558140
55	AC32-M44B28	32 MPa 28d strength ready mix concrete.	Ready Mix	32	0.4484211
56	F35-L46D28	35 MPa 28d strength ready mix concrete.	Ready Mix	35	0.5823529
57	F35-H46B28	35 MPa 28d strength ready mix concrete.	Ready Mix	35	0.5823530
58	A35-L44D07	35 MPa 28d strength ready mix concrete.	Ready Mix	35	0.5394977
59	A35-M46B03	35 MPa 28d strength ready mix concrete.	Ready Mix	35	0.4500000
60	AC35-M44B28	35 MPa 28d strength ready mix concrete.	Ready Mix	35	0.4346939

Mix Designs: 36 to 40 MPa

Table 6: **Declared products with Mix designs: 36 to 40MPa considered in this environmental product declaration**

Mix#	Unique name/ID	Short description	Product type	28 day strength, MPa	H2O to cement ratio
61	K38-L46D28 CAR	38 MPa 28d strength ready mix concrete.	Ready Mix	38	0.5256410
62	K38-H46B28 CAR	38 MPa 28d strength ready mix concrete.	Ready Mix	38	0.5069767

READY MIX CONCRETE DESIGN COMPOSITION

The following figures provide mass breakdown (kg per functional unit) of the material composition of each ready mix concrete design considered. Please note that the presented breakdown has been randomly altered by +/-10%, and is therefore only an approximation; this manipulation is to ensure confidentiality

Table 7: **Ready mix concrete composition**

Product Components	Raw Material, weight%
Cement	Proprietary
Aggregates	30-60.00
Others	0.01-5.00
Total	100.00

A1 RAW MATERIAL RECYCLED CONTENT AND MATERIAL LOSSES –

The following table provides a list of the raw material inputs (module A1) across all products considered, their recyclability content and assumed material losses.

Table 8: **Module A1 raw material inputs, the recyclability content and assumed material losses (dry basis)**

product.name	mix.category	primary.content	post.industrial. content	post.consumer. content	material. losses
Cement HE Nicragua	cement, unspecified	1	0	0	0
Water	tap water	1	0	0	0.05
Gravel	gravel, crushed	1	0	0	0.05
River sand	sand	1	0	0	0.05
Additives	chemical, organic	1	0	0	0.05

SYSTEM BOUNDARIES

The following figure depicts the cradle-to-gate system boundary considered in this study:

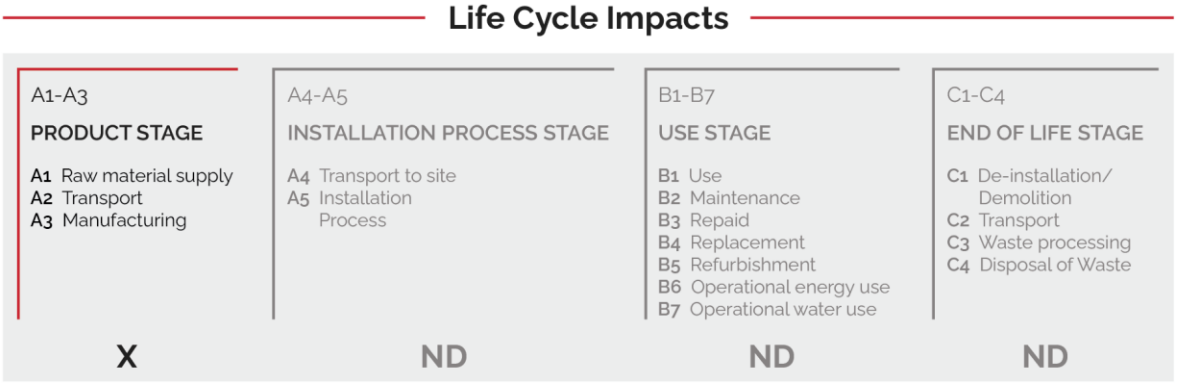

Figure 1: **General life cycle phases for consideration in a construction works system**

This is a Cradle-to-gate life cycle assessment and the following life cycle stages are included in the study:

- A1: Raw material supply (upstream processes) - Extraction, handling, and processing of the materials used in manufacturing the declared products in this LCA.
- A2: Transportation - Transportation of A1 materials from the supplier to the "gate" of the manufacturing facility (i.e. A3).

- A3: Manufacturing (core processes)- The energy and other utility inputs used to store, move, and manufacturer the declared products and to operate the facility.

As according to the PCR, the following figure illustrates the general activities and input requirements for producing cement products and is not necessarily exhaustive.

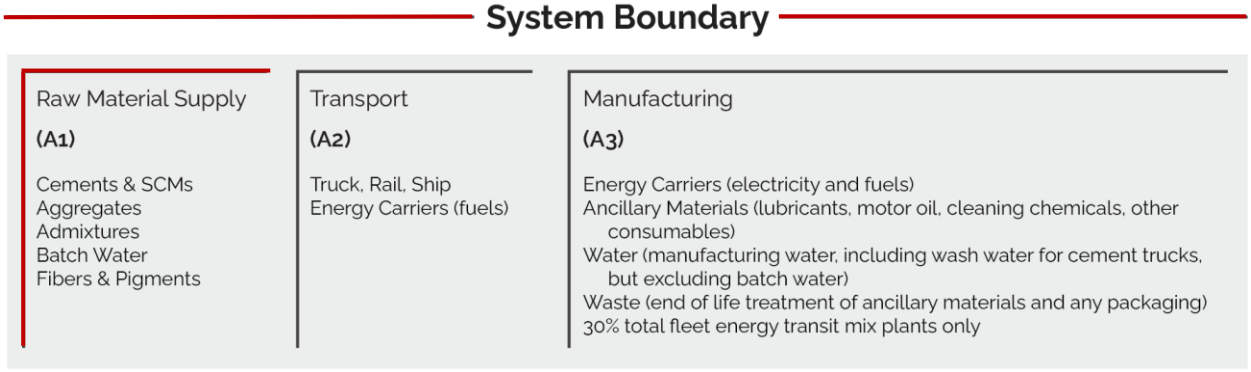

Figure 2: **General system inputs considered in the product system and categorized by modules in scope**

In addition, as according to the relevant PCR, the following requirements are excluded from this study:

- Production, manufacture, and construction of A3 building/capital goods and infrastructure.
- Production and manufacture of steel production equipment, steel delivery vehicles, earth-moving equipment, and laboratory equipment.
- Personnel-related activities (travel, furniture, office supplies).
- Energy use related to company management and sales activities.

For this LCA the manufacturing plant, owned and operated by Holcim Nicaragua, is located at their KM12 facility in Nicaragua. All operating data is formulated using the actual data from Holcim Nicaragua's plant at the above location, including water, energy consumption and waste generation. All inputs for this system boundary are calculated for the plant.

This life cycle inventory was organized in a spreadsheet and was then input into an RStudio environment where pre-calculated LCIA results for relevant products/activities stemming from the ecoinvent v3.8 database and a local EPD database in combination with primary data from Holcim Nicaragua were utilized. Explanations of the contribution of each data source to this study are outlined in the section 'Data Sources and Quality'. Further LCI details for each declared product are provided in the sections 'Detailed LCI tables' and 'Transport tables' of the detailed LCA report. A parameter uncertainty analysis was also performed where key statistical results (e.g. min/mean/max etc.) are provided in the detailed LCA report.

CUT-OFF CRITERIA

ISO 14044:2006 and the focus PCR requires the LCA model to contain a minimum of 95% of the total inflows (mass and energy) to the upstream and core modules be included in this study. The cut-off

criteria were applied to all other processes unless otherwise noted above as follows. A 1% cut-off is considered for all renewable and non-renewable primary energy consumption and the total mass of inputs within a unit process where the total of the neglected inputs does not exceed 5%.

DATA SOURCES AND DATA QUALITY ASSESSMENT

The following table summarizes the facility's (i.e. A3) electricity consumption and on-site generation or off-site contractual procurement (if applicable), process/space heating requirements, fuel inputs for on-site machinery, and waste generation.

Table 9: **Inputs required by facility from 2021-01-01 to 2021-12-31 (364 days) to produce 22336 m3 of concrete**

Activity	Value	Units
Electricity consumption and on-site generation or off-site contractual procurement (if applicable)		
Gross grid electricity:	91,560	kWh
Fuel requirements for machinery		
Diesel	10,099.2	L
Waste generation		
Wash water	2,058	m3
Hazardous waste	2,000	kg
Non-hazardous waste	5,000	kg
High-level radioactive waste	NA	kg

No recovered on-site energy occurs at this facility.

Table 10: **Reused or recycled components/materials at the A3 facility site**

Component/material for re-use/recycling	Value	Units	Re-used/recycled on-site or off-site
Returned concrete	40.32	m3	NA

The following statements explain how the above facility requirements/generation were derived:

Raw material transport: A combination of actual mode/distance combinations were assumed for key bulk materials whereas ecoinvent default multi-modal market mix distances were assumed for other inputs where no original data could be provided.

Electricity: No grid electricity is consumed at this plant. A diesel powered generator is deployed at site to meet the electricity requirements of the plant.

Process/space heating: No fuel is used for space Heating at this plant.

Fuel required for machinery: Machinery-related fuel requirements were determined from direct Holcim information. The types of machinery used include generators, pumps to pump concrete to higher elevations, and transportation equipment used for moving materials. This plant does not have electricity therefore it uses diesel to power generators.

Waste generation: Waste generation values are directly reported from Holcim operations for bulk waste. No hazardous or high-level radioactive waste is generated on-site at this facility. Wash water for trucks was also primary reported data for 2022.

Recovered energy: Not applicable.

Recycled/reused material/components: The amount of returned concrete is based on Holcim primary data for the reference year, 2022.

Module A1 material losses: Due to lack of data, default loss factors of 5% were assumed. The PCR states " A3 shall include an assumption of 5% material loss unless product specific data is available and transparently reported in the project LCA report underlying the EPD;"

Direct A3 emissions accounting: Direct emissions for the on-site machinery use the actual fuel consumption and the ecoinvent database to calculate those emissions..

Waste transport requirements: Transportation distances are using estimated values. The waste hauler cannot guarantee the exact distances traveled due to the variation of route and actual location of disposal. Most waste disposal sites are near the plant therefore the 25 km distance is a representative estimate. Returned concrete and wash water, measured in kilograms, is based on direct Holcim reporting for the reference year 2022.

Product transport requirements: The diesel fuel used by the mixing trucks is direct primary information reported from Holcim Nicaragua records for the year 2022. Holcim records their fuel for their trucks in l/km and therefore the information was converted with the following formula: (Ave. km to site)* 2 for return L diesel/km /(ave. m3 of concrete in a load) total concrete volume in m3 * fraction allocated to A3. A4 is outside the scope of this study.

The following tables depict a list of assumed life cycle inventory utilized in the LCA modeling to generate the impact results across the life cycle modules in scope. An assessment of the quality of each LCI activities utilized from various sources is also provided.

Table 11: **LCI inputs assumed for module A1 (i.e. raw material supply)** ***Data Quality Assessment Key Fair=1, Good=2, Very Good =3.***

Input	LCI.activity	Data.source	Geo	Year	Technology	Time	Geography	Reliability	Completeness
Water	tap water production, conventional with biological treatment/tap water/RoW/kg	ecoinvent v3.8	NA	v3.8 in 2021	2	3	2	3	3
Gravel	limestone quarry operation/limestone, unprocessed/RoW/kg	ecoinvent v3.8	Masaya	v3.8 in 2021	2	3	2	3	3
Additives	market for chemical, organic/chemical, organic/GLO/kg	ecoinvent v3.8	Managua	v3.8 in 2021	2	3	2	3	3
River Sand	sand quarry operation, extraction from river bed/sand/BR/kg	ecoinvent v3.8	Masaya	v3.8 in 2021	2	3	2	3	3

Cement HE Nicragua	HE Cement	Progam Operator: Labeling Sustainability- EPD ID: 2efc7137-757b-4167-b0c7-96b45c849615	León	15 June 2023	3	3	3	3	3

Table 12: **LCI inputs assumed for module A2 (i.e. transport of A1 inputs)**

Input	LCI.activity	Data.source	Geo	Year	Technology	Time	Geography	Reliability	Completeness
Additives-freight transport via Truck	market for transport, freight, lorry 7.5-16 metric ton, EURO6/transport, freight, lorry 7.5-16 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3
Cement HE Nicragua-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3
Gravel-freight transport via Truck	market for transport, freight, lorry 7.5-16 metric ton, EURO6/transport, freight, lorry 7.5-16 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3
River Sand-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3

Table 13: **LCI inputs assumed for module A3**

Input	LCI.activity	Data.source	Geo	Year	Technology	Time	Geography	Reliability	Completeness
Diesel	diesel, burned in building machine/diesel, burned in building machine/GLO/MJ	ecoinvent v3.8	GLO	v3.8 in 2021	1	3	1	3	3
Diesel used for mixing trucks	transport, freight, lorry 7.5-16 metric ton, EURO6/transport, freight, lorry 7.5-16 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	2	3	3
Grid electricity	market for electricity, medium voltage/electricity, medium voltage/SV/kWh	ecoinvent v3.8	SV	v3.8 in 2021	2	3	2	3	3
Hazardous waste	treatment of hazardous waste, hazardous waste incineration/hazardous waste, for incineration/RoW/kg	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3
Non-hazardous waste	treatment of municipal solid waste, sanitary landfill/municipal solid waste/RoW/kg	ecoinvent v3.8	RoW	v3.8 in 2021	1	3	1	3	3
Transport of Hazardous waste	transport, freight, lorry, all sizes, EURO4 to generic market for transport, freight, lorry, unspecified/transport, freight, lorry, unspecified/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3k
Transport of Non-hazardous waste	transport, freight, lorry, all sizes, EURO5 to generic market for transport, freight, lorry, unspecified/transport, freight, lorry, unspecified/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3
Transport of Returned concrete	transport, freight, lorry >32 metric ton, EURO6/transport, freight, lorry >32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3

Transport of Wash water	transport, freight, lorry >32 metric ton, EURO6/transport, freight, lorry >32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3
Wash water	tap water production, conventional with biological treatment/tap water/RoW/kg	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3

DATA QUALITY ASSESSMENT

Data quality/variability requirements, as specified in the PCR, are applied. This section describes the achieved data quality relative to the ISO 14044:2006 requirements. Data quality is judged based on its precision (measured, calculated, or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied within a study serving as a data source) and representativeness (geographical, temporal, and technological).

Precision: Through measurement and calculation, the manufacturers collected and provided primary data on their annual production. For accuracy, the LCA practitioner and 3rd Party Verifier validated the plant gate-to-gate data.

Completeness: All relevant specific processes, including inputs (raw materials, energy, and ancillary materials) and outputs (emissions and production volume) were considered and modeled to represent the specified and declared products. The majority of relevant background materials and processes were taken from ecoinvent v3.8 LCI datasets where relatively recent region-specific electricity inputs were utilized. The most relevant EPDs requiring key A1 inputs were also utilized where readily available.

Consistency: To ensure consistency, the same modeling structure across the respective product systems was utilized for all inputs, which consisted of raw material inputs and ancillary material, energy flows, water resource inputs, product, and co-products outputs, returned and recovered Cement materials, emissions to air, water and soil, and waste recycling and treatment. The same background LCI datasets from the ecoinvent v3.8 database were used across all product systems. Crosschecks concerning the plausibility of mass and energy flows were continuously conducted. The LCA team conducted mass and energy balances at the plant and selected process level to maintain a high level of consistency.

Reproducibility: Internal reproducibility is possible since the data and the models are stored and available in a machine readable project file for all foreground and background processes, and in Labeling Sustainability's proprietary Ready Mix Concrete LCA calculator* for all production facility and product-specific calculations. A considerable level of transparency is provided throughout the detailed LCA report as the specifications and material quantity make-up for the declared products are presented and key primary and secondary LCI data sources are summarized. The provision of more detailed publicly accessible data to allow full external reproducibility was not possible due to reasons of confidentiality.

*Labeling Sustainability has developed a proprietary tool that allows the calculation of PCR-compliant LCA results for Ready Mix Concrete product designs. The tool auto-calculates results by scaling base-unit technosphere inputs (i.e. 1 kg sand, 1 kWh electricity, etc.) to replicate the reference flow conversions that take place in any typical LCA software like openLCA or SimaPro. The tool was tested against several LCAs performed in openLCA and the tool generated identical results to those realized in openLCA across every impact category and inventory metric (where comparisons could be readily made).

Representativeness: The representativeness of the data is summarized as follows.

- Time related coverage of the manufacturing processes' primary collected data from 2021-01-01 to 2021-12-31.
- Upstream (background) LCI data was either the PCR specified default (if applicable) or more appropriate LCI datasets as found in the country-adjusted ecoinvent v3.8 database.
- Geographical coverage for inputs required by the A3 facility(ies) is representative of its region of focus; other upstream and background processes are based on US, North American, or global average data and adjusted to regional electricity mixes when relevant.
- Technological coverage is typical or average and specific to the participating facilities for all primary data.

ENVIRONMENTAL INDICATORS AND INVENTORY METRICS

Per the PCR, this EPD supports the life cycle impact assessment indicators and inventory metrics as listed in the tables below. As specified in the PCR, the most recent US EPA Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI), impact categories were utilized as they provide a North American context for the mandatory category indicators to be included in the EPD. Additionally, the PCR requires a set of inventory metrics to be reported with the LCIA indicators (see tables below).

Table 14: **Life cycle impact categories and life cycle inventory metrics**

ID	LCIA.indicators	Abbreviations	Units
1	environmental impact: acidification	AP	moles of H+-Eq
2	environmental impact: eutrophication	EP	kg N
3	environmental impact: global warming	GWP	kg CO2-Eq
4	environmental impact: ozone depletion	ODP	kg CFC-11-Eq
5	environmental impact: photochemical oxidation	PCOP	kg NOx-Eq
6	material resources: metals/minerals: abiotic depletion potential (ADP): elements (ultimate reserves)	ADPe	kg Sb-Eq
7	energy resources: non-renewable: abiotic depletion potential (ADP): fossil fuels	ADPf	MJ, net calorific value
Inventory metrics			
8	Total primary energy	TPE	MJ-Eq
9	Renewable energy	RE	MJ-Eq
10	Non-renewable energy	NRE	MJ-Eq
11	Non-Renewable Resources	NRR	kg
12	Renewable Resources	RR	m3
13	water depletion: WDP	WDP	m3

14	land filling: bulk waste	LFW	kg waste
15	land filling: hazardous waste	LFHW	kg waste
16	Concrete batching water consumption	CBWC	m3
17	Concrete washing water consumption	CWWC	m3
18	Concrete hazardous waste	CHW	kg
19	Concrete non-hazardous waste	CNHW	kg

A summary description of each of the impact categories and inventory metrics is provided in the following table:

Table 15: **Definitions of life cycle impact categories and life cycle inventory metrics**

Midpoint impact categories	
Global Warming Potential (GWP) (units: kg CO2-eq)	Global Warming Potential or climate change can be defined as the change in global temperature caused by the greenhouse effect that the release of greenhouse gases by human activity creates. The Environmental Profiles characterization model is based on factors developed by the United Nations Intergovernmental Panel on Climate Change (IPCC). Factors are expressed as Global Warming Potential over the time horizon of different years, being the most common 100 years (GWP100), measured in the reference unit, kg CO2 equivalent.
Ozone Depletion Potential (ODP) (kg CFC-11-eq)	Ozone-depleting gases cause damage to stratospheric ozone or the ozone layer. CFCs, halons and HCFCs are the major causes of ozone depletion. The characterization model has been developed by the World Meteorological Organization (WMO) and defines the ozone depletion potential of different gases relative to the reference substance chlorofluorocarbon-11 (CFC-11), expressed in kg CFC-11 equivalent.
Acidification Potential (AP) (kg SO2-eq)	Acidic gases such as Sulphur dioxide (SO2) react with water in the atmosphere to form acid rain, a process known as acid deposition. Acidification potential is expressed using the reference unit, kg SO2 equivalent. The model does not take account of regional differences in terms of which areas are more or less susceptible to acidification. It accounts only for acidification caused by SO2 and NOx. This includes acidification due to fertilizer use, according to the method developed by the Intergovernmental Panel on Climate Change (IPCC). CML has based the characterization factor on the RAINS model developed by the University of Amsterdam.
Eutrophication Potential (EP) (PO4 3- -eq)	Eutrophication is the build-up of a concentration of chemical nutrients in an ecosystem which leads to abnormal productivity. This causes excessive plant growth like algae in rivers which causes severe reductions in water quality and animal populations. This category is based on the work of Heijungs, and is expressed using the reference unit, kg PO4 3- equivalents. Direct and indirect impacts of fertilizers are included in the method. The direct impacts are from production of the fertilizers and the indirect ones are calculated using the IPCC method to estimate emissions to water causing eutrophication.
Photochemical Ozone Creation/Smog Potential (POCP) (kg O3-eq)	Ozone is protective in the stratosphere, but on the ground-level, it is toxic to humans in high concentration. Photochemical ozone, also called ground-level ozone, is formed by the reaction of volatile organic compounds and nitrogen oxides in the presence of heat and sunlight. The impact category depends largely on the amounts of carbon monoxide (CO), Sulphur dioxide (SO2), nitrogen oxide (NO), ammonium and NMVOC (non-methane volatile organic compounds). Photochemical ozone creation potential (also known as summer

	smog) for emission of substances to air is calculated with the United Nations Economic Commission for 22 Europe (UNECE) trajectory model (including fate) and expressed using the reference unit, kg ethylene (C_2H_4) equivalent.
Abiotic Depletion Potential (ADPel and ADPff) (kg Sb-eq)	The main concern of this category is the health of humans and the ecosystem and how it is affected by the extraction of minerals and fossil fuels, which are inputs into the system. For each extraction of minerals and fossil fuels, the abiotic depletion factor is determined. This indicator is on a global scale and is based on the concentration reserves and rate of deaccumulation. The results are presented in units of the reference element strontium (i.e. Sb). For the purposes of this EPD, this impact category is split between mineral elements (i.e. ADPel) and fossil fuels (i.e. ADPff).
Inventory metrics	
Depletion of non-renewable material resources (NRM) (kg)	This indicator covers the cumulative life cycle consumption of non-renewable resources that are extracted from the ground but not including energy resources like coal, oil and natural gas. This indicator includes the consumption of metallic ores, aggregates, and other minerals. The units of measure are in terms of kilograms material extracted and utilized/wasted in the life cycle system considered.
Use of renewable material resources (RM) (kg)	This indicator covers the cumulative life cycle consumption of renewable resources that are extracted from nature like sustainably harvested biomass. The units of measure are in terms of kilograms material extracted and utilized/wasted in the life cycle system considered.
Depletion of non-renewable energy resources (NRE) (MJ HHV)	This indicator considers the cumulative life cycle consumption of non-renewable energy resources like oil, natural gas, and coal. The units of measure are in terms of Mega-Joules of energy resource extracted and utilized/wasted in the life cycle system considered.
Use of renewable primary energy (RE) (MJ HHV)	This indicator considers the cumulative life cycle extraction of renewable energy resources from nature like solar and wind energy as well as biomass for energy purposes. The units of measure are in terms of Mega-Joules of energy resource extracted and utilized/wasted in the life cycle system considered.
Total primary energy consumption (PEC) (MJ HHV)	This indicator is the summation of non-renewable and renewable energy extracted from nature, where the units of measure are in terms of Mega-Joules of energy resource extracted/utilized/wasted in the life cycle system considered.
Water Depletion Potential (WDP) (m3)	This indicator considers the cumulative life cycle consumption of water required to produced the declared functional unit of a given product. The units of measure are in cubic meters of water consumed.
Concrete batching water consumption (CBWC) (m3)	This indicator is defined as the direct water used in concrete mix batches. The units of measure are in cubic meters of water consumed.
Concrete washing water consumption (CWWC) (m3)	This indicator is defined as the direct washing water used at the facility. The units of measure are in cubic meters of wash water consumed.
Concrete hazardous waste (CHW) (kg)	This indicator considers the amount of hazardous waste waste generated at the concrete facility. The units of measure are in kilograms of waste generated.
Concrete non-hazardous waste (CNHW) (kg)	This indicator considers the direct amount of non-hazardous waste generated at the concrete facility. The units of measure are in kilograms of waste generated.

It should be noted that emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in any of the following categories.

- Renewable primary energy resources as energy (fuel);
- Renewable primary resources as material;
- Non-renewable primary resources as energy (fuel);
- Non-renewable primary resources as material;
- Secondary Materials;
- Renewable secondary fuels;
- Non-renewable secondary fuels;
- Recovered energy;
- Abiotic depletion potential for non-fossil mineral resources.
- Land use related impacts, for example on biodiversity and/or soil fertility;
- Toxicological aspects;
- Emissions from land use change [GWP 100 (land-use change)];
- Hazardous waste disposed;
- Non-hazardous waste disposed;
- High-level radioactive waste;
- Intermediate and low-level radioactive waste;
- Components for reuse;
- Materials for recycling;
- Materials for energy recovery;
- Recovered energy exported from the product system.

TOTAL IMPACT SUMMARY

The following table reports the total LCA results for each product produced at the given cement facility on a per 1m3 of concrete basis.

Mix Designs: 0 to 15 MPa

Table 16: **Total life cycle (across modules in scope) impact results for All declared products, assuming the geometric mean point values on a per 1 m3 of concrete basis.**

a) Midpoint Impact Categories:

Indicator/LCI Metric	AP	EP	GWP	ODP	PCOP	ADPe	ADPf
Unit	**moles of H+-Eq**	**kg N**	**kg CO2-Eq**	**kg CFC-11-Eq**	**kg NOx-Eq**	**kg Sb-Eq**	**MJ, net calorific value**
Minimum	14.9	0.0199	70.5	5.89e-06	0.252	0.000286	519
Maximum	55.3	0.0645	374	1.8e-05	0.862	0.00163	1950
Mean	41	0.0486	266	1.37e-05	0.646	0.00115	1430
Median	43	0.0508	281	1.42e-05	0.675	0.00122	1500
F05-H44B28	14.9	0.0199	70.5	5.89e-06	0.252	0.000286	519
R03-H00B28 RF	23.2	0.029	136	8.48e-06	0.376	0.000578	837
M36-L68D28	37.8	0.0451	241	1.27e-05	0.597	0.00104	1320
M36-L68D14	43	0.0508	281	1.42e-05	0.675	0.00122	1500
M36-L68D03	46.8	0.055	309	1.54e-05	0.733	0.00134	1630
M39-L68D14	42	0.0497	273	1.39e-05	0.66	0.00118	1460
M39-L68D03	47.7	0.056	317	1.56e-05	0.746	0.00138	1660

M40-M68D14	32.2	0.0388	200	1.09e-05	0.51	0.000866	1120
M40-L68D14	41.3	0.0488	268	1.37e-05	0.65	0.00116	1420
R04-H00B28 RF	45.5	0.0535	309	1.53e-05	0.714	0.00133	1620
M42-L68D28	43.2	0.0511	281	1.43e-05	0.678	0.00122	1510
M42-L68D07	46.8	0.0551	309	1.54e-05	0.734	0.00134	1630
M42-L68D03	51	0.0597	341	1.67e-05	0.797	0.00148	1780
M45-L67D28	44.3	0.0524	290	1.46e-05	0.695	0.00126	1550
M45-L68D03	53.1	0.0619	357	1.73e-05	0.828	0.00155	1850
M48-L68D28	47	0.0553	310	1.54e-05	0.735	0.00135	1650
M48-L68D03	55.3	0.0645	374	1.8e-05	0.862	0.00163	1950
R05-H00B28 RF	43.8	0.0516	296	1.48e-05	0.688	0.00127	1560
F07-H44B28	30	0.0368	182	1.06e-05	0.483	0.000776	1060
F10-L46D28	33.5	0.0405	206	1.14e-05	0.535	0.000883	1150
F10-M44B28	35.8	0.043	225	1.21e-05	0.568	0.000968	1240
A10-L46D07	38.9	0.0464	246	1.3e-05	0.615	0.00106	1340
A10-H44B07	42.3	0.0501	275	1.4e-05	0.666	0.00119	1470
A10-M44B03	46.5	0.0548	306	1.53e-05	0.729	0.00133	1620
F14-L46D28	34.5	0.0416	213	1.17e-05	0.55	0.000917	1180
F14-M44B28	36.8	0.0441	233	1.24e-05	0.584	0.001	1270
A14-H46B14	39.9	0.0475	255	1.33e-05	0.631	0.0011	1380
A14-H44B07	43.4	0.0514	283	1.44e-05	0.684	0.00123	1510
A14-M44B03	47.5	0.0559	314	1.56e-05	0.745	0.00136	1660

b) Inventory Metrics:

Indicator/LCI Metric	**TPE**	**RE**	**NRE**	**NRR**	**RR**	**WDP**	**LFW**	**LFHW**	**CBWC**	**CWWC**	**CHW**	**CNHW**
Unit	**MJ-Eq**	**MJ-Eq**	**MJ-Eq**	**kg**	**m3**	**m3**	**kg waste**	**kg waste**	**m3**	**m3**	**kg**	**kg**
Minimum	583	36.2	547	15.8	0.000363	8.47	7.89	0.000808	0.183	9.21e-05	0.0895	0.224
Maximum	2190	147	2050	66.2	0.00183	14.8	21.3	0.00177	0.262	9.21e-05	0.0895	0.224
Mean	1610	108	1500	48.1	0.00133	10.5	16.6	0.00142	0.213	9.21e-05	0.0895	0.224
Median	1690	113	1580	50.9	0.0014	9.77	17.2	0.00146	0.215	9.21e-05	0.0895	0.224
F05-H44B28	583	36.2	547	15.8	0.000363	14.7	7.89	0.000808	0.262	9.21e-05	0.0895	0.224
R03-H00B28 RF	939	60.4	880	27	0.000691	13.8	10.6	0.000999	0.21	9.21e-05	0.0895	0.224
M36-L68D28	1480	98.6	1380	44.2	0.00121	10.3	15.5	0.00134	0.215	9.21e-05	0.0895	0.224
M36-L68D14	1690	113	1580	50.9	0.00137	9.52	17.2	0.00146	0.215	9.21e-05	0.0895	0.224
M36-L68D03	1830	124	1690	55.1	0.00152	9.33	18.5	0.00156	0.21	9.21e-05	0.0895	0.224
M39-L68D14	1640	111	1530	49.5	0.00141	9.42	16.9	0.00144	0.215	9.21e-05	0.0895	0.224

M39-L68D03	1870	127	1730	56.8	0.00157	9.18	18.7	0.00157	0.215	9.21e-05	0.0895	0.224
M40-M68D14	1250	83.3	1160	37.2	0.00104	8.94	13.6	0.00118	0.215	9.21e-05	0.0895	0.224
M40-L68D14	1600	109	1480	48	0.00135	9.33	16.6	0.00141	0.215	9.21e-05	0.0895	0.224
R04-H00B28 RF	1830	123	1690	55.3	0.00153	13.2	17.8	0.00154	0.215	9.21e-05	0.0895	0.224
M42-L68D28	1700	113	1590	51.1	0.00139	8.99	17.3	0.00147	0.21	9.21e-05	0.0895	0.224
M42-L68D07	1830	123	1700	55.2	0.00152	8.99	18.5	0.00156	0.21	9.21e-05	0.0895	0.224
M42-L68D03	2000	135	1850	60.5	0.0017	9.04	19.8	0.00166	0.215	9.21e-05	0.0895	0.224
M45-L67D28	1740	116	1630	52.2	0.00147	9.38	17.7	0.0015	0.2	9.21e-05	0.0895	0.224
M45-L68D03	2090	141	1930	62.8	0.00177	8.98	20.5	0.00171	0.215	9.21e-05	0.0895	0.224
M48-L68D28	1840	124	1720	55.8	0.00158	8.47	18.6	0.00156	0.205	9.21e-05	0.0895	0.224
M48-L68D03	2190	147	2050	66.2	0.00183	8.91	21.3	0.00177	0.215	9.21e-05	0.0895	0.224
R05-H00B28 RF	1760	118	1640	53	0.00146	13.1	17.2	0.00149	0.215	9.21e-05	0.0895	0.224
F07-H44B28	1190	77.1	1110	34.8	0.000931	14.8	13.1	0.00121	0.21	9.21e-05	0.0895	0.224
F10-L46D28	1290	86.4	1200	38.1	0.00106	11.3	14.2	0.00126	0.183	9.21e-05	0.0895	0.224
F10-M44B28	1390	92.9	1300	41.3	0.00113	11.1	14.9	0.00131	0.219	9.21e-05	0.0895	0.224
A10-L46D07	1500	101	1400	44.9	0.00122	10.5	16	0.00139	0.183	9.21e-05	0.0895	0.224
A10-H44B07	1650	111	1540	49.3	0.0014	9.67	17	0.00145	0.23	9.21e-05	0.0895	0.224
A10-M44B03	1820	123	1690	55.1	0.00151	9.83	18.4	0.00156	0.219	9.21e-05	0.0895	0.224
F14-L46D28	1330	88.1	1240	39.5	0.0011	11.2	14.6	0.00129	0.185	9.21e-05	0.0895	0.224
F14-M44B28	1430	96	1330	42.7	0.00115	11	15.3	0.00133	0.222	9.21e-05	0.0895	0.224
A14-H46B14	1540	105	1450	46.6	0.00132	10.4	16.3	0.00141	0.206	9.21e-05	0.0895	0.224
A14-H44B07	1700	115	1590	50.9	0.00145	10.5	17.4	0.00149	0.232	9.21e-05	0.0895	0.224
A14-M44B03	1860	125	1740	56	0.00158	9.77	18.8	0.00159	0.222	9.21e-05	0.0895	0.224

Mix Designs: 15 to 20 MPa

Table 17: **Total life cycle (across modules in scope) impact results for All declared products, assuming the geometric mean point values on a per 1 m3 of concrete basis.**

a) Midpoint Impact Categories:

Indicator/LCI Metric	AP	EP	GWP	ODP	PCOP	ADPe	ADPf
Unit	**moles of H+-Eq**	**kg N**	**kg CO2-Eq**	**kg CFC-11-Eq**	**kg NOx-Eq**	**kg Sb-Eq**	**MJ, net calorific value**
Minimum	35.5	0.0427	221	1.2e-05	0.565	0.000951	1220
Maximum	49.9	0.0585	332	1.63e-05	0.78	0.00144	1740
Mean	42.4	0.0503	274	1.41e-05	0.668	0.00118	1470
Median	42	0.0498	271	1.4e-05	0.662	0.00117	1460
F18-L46D28	35.5	0.0427	221	1.2e-05	0.565	0.000951	1220
F18-H46B28	38.3	0.0458	243	1.28e-05	0.607	0.00105	1320
A18-L44D07	42	0.0498	271	1.4e-05	0.662	0.00117	1460
A18-L46D03	46.2	0.0546	302	1.53e-05	0.727	0.00131	1610
A18-H44B03	49.9	0.0585	332	1.63e-05	0.78	0.00144	1740

b) Inventory Metrics:

Indicator/LCI Metric	TPE	RE	NRE	NRR	RR	WDP	LFW	LFHW	CBWC	CWWC	CHW	CNHW
Unit	**MJ-Eq**	**MJ-Eq**	**MJ-Eq**	**kg**	**m3**	**m3**	**kg waste**	**kg waste**	**m3**	**m3**	**kg**	**kg**
Minimum	1360	91.3	1280	40.7	0.00111	9.37	14.9	0.00131	0.187	9.21e-05	0.0895	0.224
Maximum	1950	131	1820	59	0.00165	11.2	19.5	0.00164	0.234	9.21e-05	0.0895	0.224
Mean	1650	111	1540	49.5	0.00137	10.5	17.1	0.00147	0.206	9.21e-05	0.0895	0.224
Median	1630	110	1520	49	0.00137	10.4	17	0.00147	0.208	9.21e-05	0.0895	0.224
F18-L46D28	1360	91.3	1280	40.7	0.00111	11.2	14.9	0.00131	0.187	9.21e-05	0.0895	0.224
F18-H46B28	1490	99.3	1380	44.3	0.00124	10.4	15.8	0.00137	0.208	9.21e-05	0.0895	0.224
A18-L44D07	1630	110	1520	49	0.00137	11.1	17	0.00147	0.213	9.21e-05	0.0895	0.224
A18-L46D03	1800	121	1680	54.5	0.00148	10.2	18.4	0.00157	0.187	9.21e-05	0.0895	0.224
A18-H44B03	1950	131	1820	59	0.00165	9.37	19.5	0.00164	0.234	9.21e-05	0.0895	0.224

Mix Designs: 21 to 25 MPa

Table 18: **Total life cycle (across modules in scope) impact results for All declared products, assuming the geometric mean point values on a per 1 m3 of concrete basis.**

a) Midpoint Impact Categories:

Indicator/LCI Metric	AP	EP	GWP	ODP	PCOP	ADPe	ADPf
Unit	**moles of H+-Eq**	**kg N**	**kg CO2-Eq**	**kg CFC-11-Eq**	**kg NOx-Eq**	**kg Sb-Eq**	**MJ, net calorific value**
Minimum	37.1	0.0445	233	1.25e-05	0.589	0.00101	1280
Maximum	56.8	0.0661	386	1.85e-05	0.886	0.00168	1990
Mean	45.7	0.0539	299	1.51e-05	0.718	0.0013	1590
Median	44.8	0.053	293	1.48e-05	0.705	0.00127	1560
F21-L46D28	37.1	0.0445	233	1.25e-05	0.589	0.00101	1280
F21-H46B28	40.1	0.0477	257	1.34e-05	0.633	0.00111	1390
A21-L44D07	43.6	0.0516	284	1.45e-05	0.686	0.00123	1520
A21-L46D03	48.2	0.0568	315	1.59e-05	0.757	0.00137	1670
A21-H44B03	51.8	0.0607	346	1.69e-05	0.81	0.0015	1810
E21-M46B28 Espec	56.8	0.0661	386	1.85e-05	0.886	0.00168	1990
F24-L46D28	39.2	0.0467	249	1.31e-05	0.62	0.00107	1350
F24-H46B28	42.3	0.0501	274	1.4e-05	0.666	0.00119	1470
A24-M46B07	46.1	0.0544	302	1.52e-05	0.724	0.00131	1600
A24-M46B03	51.4	0.0603	342	1.68e-05	0.804	0.00149	1800

b) Inventory Metrics:

Indicator/LCI Metric	TPE	RE	NRE	NRR	RR	WDP	LFW	LFHW	CBWC	CWWC	CHW	CNHW
Unit	**MJ-Eq**	**MJ-Eq**	**MJ-Eq**	**kg**	**m3**	**m3**	**kg waste**	**kg waste**	**m3**	**m3**	**kg**	**kg**
Minimum	1430	95.9	1340	42.7	0.00119	9.2	15.4	0.00134	0.189	9.21e-05	0.0895	0.224
Maximum	2240	151	2080	67.6	0.0019	10.7	21.7	0.00181	0.236	9.21e-05	0.0895	0.224
Mean	1780	120	1660	53.6	0.0015	10.1	18.2	0.00155	0.204	9.21e-05	0.0895	0.224
Median	1740	118	1640	52.6	0.00148	10	17.9	0.00153	0.202	9.21e-05	0.0895	0.224
F21-L46D28	1430	95.9	1340	42.7	0.00119	10.7	15.4	0.00134	0.189	9.21e-05	0.0895	0.224
F21-H46B28	1550	104	1440	46.5	0.0013	9.98	16.3	0.0014	0.21	9.21e-05	0.0895	0.224
A21-L44D07	1700	114	1600	51	0.00143	10.5	17.5	0.0015	0.215	9.21e-05	0.0895	0.224
A21-L46D03	1880	126	1750	56.5	0.00158	10.4	19.1	0.00163	0.189	9.21e-05	0.0895	0.224
A21-H44B03	2020	138	1890	61.6	0.00178	9.54	20.2	0.0017	0.236	9.21e-05	0.0895	0.224

E21-M46B28 Espec	2240	151	2080	67.6	0.00191	9.65	21.7	0.00181	0.194	9.21e-05	0.0895	0.224
F24-L46D28	1510	101	1410	45.3	0.00124	10.6	16.1	0.00139	0.191	9.21e-05	0.0895	0.224
F24-H46B28	1640	110	1530	49.4	0.00136	9.88	17.1	0.00146	0.212	9.21e-05	0.0895	0.224
A24-M46B07	1790	122	1680	54.3	0.00153	10.1	18.3	0.00156	0.202	9.21e-05	0.0895	0.224
A24-M46B03	2020	136	1880	61.3	0.00166	9.2	20.1	0.00168	0.202	9.21e-05	0.0895	0.224

Mix Designs: 26 to 30 MPa

Table 19: **Total life cycle (across modules in scope) impact results for All declared products, assuming the geometric mean point values on a per 1 m3 of concrete basis.**

a) Midpoint Impact Categories:

Indicator/LCI Metric	**AP**	**EP**	**GWP**	**ODP**	**PCOP**	**ADPe**	**ADPf**
Unit	**moles of H+-Eq**	**kg N**	**kg CO2-Eq**	**kg CFC-11-Eq**	**kg NOx-Eq**	**kg Sb-Eq**	**MJ, net calorific value**
Minimum	40.7	0.0484	260	1.35e-05	0.642	0.00113	1400
Maximum	69	0.0796	479	2.21e-05	1.07	0.00209	2430
Mean	52.6	0.0616	352	1.72e-05	0.823	0.00153	1840
Median	50.4	0.059	334	1.65e-05	0.788	0.00145	1760
F28-L46D28	40.7	0.0484	260	1.35e-05	0.642	0.00113	1400
F28-H46B28	44	0.0519	286	1.45e-05	0.691	0.00124	1520
A28-M46B07	47.7	0.0561	314	1.57e-05	0.747	0.00136	1660
A28-M46B03	53	0.062	354	1.73e-05	0.828	0.00154	1850
X28-M46B28 Espec	61.5	0.0715	419	1.99e-05	0.959	0.00182	2150
CAD700-H44B28	69	0.0796	479	2.21e-05	1.07	0.00209	2430

b) Inventory Metrics:

Indicator/LCI Metric	**TPE**	**RE**	**NRE**	**NRR**	**RR**	**WDP**	**LFW**	**LFHW**	**CBWC**	**CWWC**	**CHW**	**CNHW**
Unit	**MJ-Eq**	**MJ-Eq**	**MJ-Eq**	**kg**	**m3**	**m3**	**kg waste**	**kg waste**	**m3**	**m3**	**kg**	**kg**
Minimum	1570	105	1470	47.1	0.00131	8.55	16.6	0.00142	0.193	9.21e-05	0.0895	0.224
Maximum	2720	187	2540	83.2	0.00233	9.98	25.7	0.00211	0.242	9.21e-05	0.0895	0.224
Mean	2060	140	1920	62.3	0.00175	9.4	20.4	0.00171	0.208	9.21e-05	0.0895	0.224
Median	1980	133	1830	59.6	0.00166	9.37	19.7	0.00166	0.204	9.21e-05	0.0895	0.224

F28-L46D28	1570	105	1470	47.1	0.00131	9.98	16.6	0.00142	0.193	9.21e-05	0.0895	0.224
F28-H46B28	1710	115	1590	51.2	0.00146	9.28	17.6	0.00149	0.214	9.21e-05	0.0895	0.224
A28-M46B07	1870	126	1730	56.1	0.00155	9.46	18.8	0.00159	0.204	9.21e-05	0.0895	0.224
A28-M46B03	2080	140	1930	63	0.00176	9.13	20.6	0.00172	0.204	9.21e-05	0.0895	0.224
X28-M46B28 Espec	2410	164	2260	73.4	0.00208	9.97	23.4	0.00195	0.194	9.21e-05	0.0895	0.224
CAD700-H44B28	2720	187	2540	83.2	0.00233	8.55	25.7	0.00211	0.242	9.21e-05	0.0895	0.224

Mix Designs: 31 to 35 MPa

Table 20: **Total life cycle (across modules in scope) impact results for All declared products, assuming the geometric mean point values on a per 1 m3 of concrete basis.**

a) Midpoint Impact Categories:

Indicator/LCI Metric	**AP**	**EP**	**GWP**	**ODP**	**PCOP**	**ADPe**	**ADPf**
Unit	**moles of H+-Eq**	**kg N**	**kg CO2-Eq**	**kg CFC-11-Eq**	**kg NOx-Eq**	**kg Sb-Eq**	**MJ, net calorific value**
Minimum	42.2	0.0501	272	1.4e-05	0.665	0.00118	1460
Maximum	60.8	0.0705	415	1.96e-05	0.944	0.00181	2140
Mean	50.9	0.0596	339	1.66e-05	0.796	0.00147	1780
Median	50.4	0.0592	334	1.66e-05	0.79	0.00145	1760
F32-L46D28	42.2	0.0501	272	1.4e-05	0.665	0.00118	1460
F32-H46B28	45.6	0.0538	299	1.5e-05	0.716	0.0013	1590
A32-L44D07	49.9	0.0586	331	1.64e-05	0.782	0.00143	1740
A32-M46B03	54.6	0.0638	367	1.78e-05	0.852	0.0016	1910
AC32-M44B28	59.2	0.0688	403	1.92e-05	0.921	0.00175	2080
F35-L46D28	43.2	0.0512	280	1.43e-05	0.68	0.00121	1500
F35-H46B28	46.7	0.055	307	1.53e-05	0.732	0.00133	1620
A35-L44D07	50.9	0.0598	338	1.67e-05	0.798	0.00147	1780
A35-M46B03	55.7	0.0649	375	1.81e-05	0.868	0.00163	1950
AC35-M44B28	60.8	0.0705	415	1.96e-05	0.944	0.00181	2140

b) Inventory Metrics:

Indicator/LCI Metric	**TPE**	**RE**	**NRE**	**NRR**	**RR**	**WDP**	**LFW**	**LFHW**	**CBWC**	**CWWC**	**CHW**	**CNHW**
Unit	**MJ-Eq**	**MJ-Eq**	**MJ-Eq**	**kg**	**m3**	**m3**	**kg waste**	**kg waste**	**m3**	**m3**	**kg**	**kg**
Minimum	2410	163	2230	73.2	0.00205	10.2	23	0.00191	0.224	9.21e-05	0.0895	0.224

Maximum	2410	163	2230	73.2	0.00205	10.2	23	0.00191	0.224	9.21e-05	0.0895	0.224
Mean	2000	135	1860	60.4	0.00169	9.35	19.9	0.00167	0.213	9.21e-05	0.0895	0.224
Median	1980	133	1840	59.8	0.00168	9.1	19.8	0.00168	0.217	9.21e-05	0.0895	0.224
F32-L46D28	1640	110	1520	49.7	0.00136	9.91	17.1	0.00146	0.195	9.21e-05	0.0895	0.224
F32-H46B28	1780	120	1670	53.9	0.00152	9.21	18.1	0.00153	0.216	9.21e-05	0.0895	0.224
A32-L44D07	1960	132	1830	58.8	0.00166	10.2	19.6	0.00166	0.222	9.21e-05	0.0895	0.224
A32-M46B03	2150	145	2010	65.2	0.00183	8.89	21.1	0.00176	0.206	9.21e-05	0.0895	0.224
AC32-M44B28	2340	158	2170	70.7	0.00197	8.96	22.5	0.00187	0.224	9.21e-05	0.0895	0.224
F35-L46D28	1680	114	1560	50.6	0.0014	9.67	17.4	0.00148	0.197	9.21e-05	0.0895	0.224
F35-H46B28	1820	123	1700	55	0.00155	8.98	18.5	0.00156	0.218	9.21e-05	0.0895	0.224
A35-L44D07	2000	134	1850	60.7	0.00171	10.1	19.9	0.00169	0.224	9.21e-05	0.0895	0.224
A35-M46B03	2190	148	2030	66.3	0.00188	8.84	21.4	0.00179	0.208	9.21e-05	0.0895	0.224
AC35-M44B28	2410	163	2230	73.2	0.00205	8.72	23	0.00191	0.224	9.21e-05	0.0895	0.224

Mix Designs: 36 to 40 MPa

Table 21: **Total life cycle (across modules in scope) impact results for All declared products, assuming the geometric mean point values on a per 1 m3 of concrete basis.**

a) Midpoint Impact Categories:

Indicator/LCI Metric	**AP**	**EP**	**GWP**	**ODP**	**PCOP**	**ADPe**	**ADPf**
Unit	**moles of H+-Eq**	**kg N**	**kg CO2-Eq**	**kg CFC-11-Eq**	**kg NOx-Eq**	**kg Sb-Eq**	**MJ, net calorific value**
Minimum	50	0.0586	334	1.63e-05	0.781	0.00145	1750
Maximum	53.9	0.0627	364	1.75e-05	0.842	0.00157	1850
Mean	52	0.0606	349	1.69e-05	0.812	0.00151	1800
Median	52	0.0606	349	1.69e-05	0.812	0.00151	1800
K38-L46D28 CAR	50	0.0586	334	1.63e-05	0.781	0.00145	1750
K38-H46B28 CAR	53.9	0.0627	364	1.75e-05	0.842	0.00157	1850

b) Inventory Metrics:

Indicator/LCI Metric	TPE	RE	NRE	NRR	RR	WDP	LFW	LFHW	CBWC	CWWC	CHW	CNHW
Unit	MJ-Eq	MJ-Eq	MJ-Eq	kg	m3	m3	kg waste	kg waste	m3	m3	kg	kg
Minimum	1980	133	1830	59.5	0.00166	8.82	19.5	0.00163	0.215	9.21e-05	0.0895	0.224
Maximum	2090	144	1940	62.8	0.00181	9.33	20.7	0.00173	0.229	9.21e-05	0.0895	0.224
Mean	2040	138	1880	61.2	0.00174	9.07	20.1	0.00168	0.222	9.21e-05	0.0895	0.224
Median	2040	138	1880	61.2	0.00174	9.07	20.1	0.00168	0.222	9.21e-05	0.0895	0.224
K38-L46D28 CAR	1980	133	1830	59.5	0.00166	8.82	19.5	0.00163	0.215	9.21e-05	0.0895	0.224
K38-H46B28 CAR	2090	144	1940	62.8	0.00181	9.33	20.7	0.00173	0.229	9.21e-05	0.0895	0.224

ADDITIONAL ENVIRONMENTAL INFO

No regulated substances of very high concern are utilized on site.

REFERENCES

ASTM Standards:

- ASTM A36/A36M Standard Specification for Carbon Structural Steel
- ASTM A108 Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
- ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- ASTM A184 Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement
- ASTM A307 Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength
- ASTM A416/A416M Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
- ASTM A555/A555M Standard Specification for General Requirements for Stainless Steel Wire and Wire Rods
- ASTM A615/A615M Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- ASTM A666 Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

- ASTM A706/A706M Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
- ASTM A767/A767M Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
- ASTM A775/A775M Standard Specification for Epoxy-Coated Steel Reinforcing Bars
- ASTM A820/A820M Standard Specification for Steel Fibers for Fiber-Reinforced Concrete
- ASTM A884/A884M Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement
- ASTM A934/A934M Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
- ASTM A1064/A1064M Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
- ASTM C33/C33M Standard Specification for Concrete Aggregates
- ASTM C94 Standard Specification for Ready-Mixed Concrete
- ASTM C150/C150M Standard Specification for Portland Cement
- ASTM C260/C260M Standard Specification for Air-Entraining Admixtures for Concrete
- ASTM C595 Standard Specification for Blended Hydraulic Cements
- ASTM C618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
- ASTM C979/C979M Standard Specification for Pigments for Integrally Colored Concrete
- ASTM C989/C989M Standard Specification for Slag Cement for Use in Concrete and Mortars
- ASTM C1017/C1017M Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
- ASTM C1116/C1116M Standard Specification for Fiber-Reinforced Concrete
- ASTM C1157/C1157M Standard Performance Specification for Hydraulic Cement
- ASTM C1240 Standard Specification for Silica Fume Used in Cementitious Mixtures
- ASTM C1602/C1602M Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
- ASTM G109 Standard Test Method for Determining Effects of Chemical Admixtures on Corrosion of Embedded Steel Reinforcement in Concrete Exposed to Chloride Environments
- ASTM C330/C330M Standard Specification for Lightweight Aggregates for Structural Concrete
- ASTM C494/C494M Standard Specification for Chemical Admixtures for Concrete

CSA Standards:

- CAN/CGSB-1.40 Anticorrosive Structural Steel Alkyd Primer
- CAN/CSA G30.18 Carbon steel bars for concrete reinforcement
- CAN/CSA A3000 Cementitious Materials Compendium
- CAN/CSA G40.20/G40.21 General requirements for rolled or welded structural quality steel / Structural quality steel
- CAN/CSA A23.1/A23.2 Concrete Materials and Methods of Concrete Construction/Test methods and Standard Practices for Concrete

- CAN/CSA A23.4 Precast concrete - Materials and construction
- CSA S806 Design and construction of building structures with fiber-reinforced polymers

ISO Standards:

- ISO 6707-1: 2014 Buildings and Civil Engineering Works - Vocabulary - Part 1: General Terms
- ISO 14021:1999 Environmental Labels and Declarations - Self-declared Environmental Claims (Type II Environmental Labeling)
- ISO 14025:2006 Environmental Labels and Declarations - Type III Environmental Declarations - Principles and Procedures
- ISO 14040:2006 Environmental Management - Life Cycle Assessment - Principles and Framework
- ISO 14044:2006 Environmental Management - Life Cycle Assessment - Requirements and Guidelines
- ISO 14067:2018 Greenhouse Gases - Carbon Footprint of Products - Requirements and Guidelines for Quantification
- ISO 14050:2009 Environmental Management - Vocabulary
- ISO 21930:2017 Sustainability in Building Construction - Environmental Declaration of Building Products

EN Standards:

- EN 16757 Sustainability of construction works - Environmental product declarations - Product Category Rules for concrete and concrete elements
- EN 15804 Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products

Other References:

- US EPA Waste Reduction Model (WARM), Fly Ash Chapter: http://epa.gov/climatechange/wycd/waste/downloads/fly-ash-chapter10-28-10.pdf
- American Concrete Institute (ACI) 211: Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
- ACI 318-14 Building Code Requirements for Structural Concrete and Commentary. American Concrete Institute. Farmington Hills, MI, USA available at https://www.concrete.org/store/
- Mather, B & Ozyildirim, C. (2002). SP-1(02) : Concrete Primer. American Concrete Institute: SP0102. American Concrete Institute. Farmington Hills, MI, USA available at https://www.concrete.org/store/
- NSF International (February 2019). Product Category Rules (PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) of Concrete v1.2.
- Product Category Rules for Preparing an Environmental Product Declaration for Precast Concrete (UN CPC 37550), ASTM International, March 2015. https://www.astm.org/CERTIFICATION/DOCS/266.PCR_for_Precast_Concrete.pdf

- USGBC LEED v4 for Building Design and Construction, 11 Jan 2019 available at https://www.usgbc.org/resources/pcr-committee-process-resources-part-b
- USGBC PCR Committee Process & Resources: Part B, USGBC, 7 July 2017 available at https://www.usgbc.org/resources/pcr-committee-process-resources-part-b.