Environmental Product Declaration

Environmental Product Declaration for ready mix concrete products produced by Concreto de Morelos S.A. de C.V. at their Polotitlan facility in Estado de México

ADMINISTRATIVE INFORMATION

International Certified Environmental Product Declaration

Declared Product:	This Environmental Product Declaration (EPD) covers ready mix concrete products produced by Concreto de Morelos S.A de C.V.. Declared unit: 1 m3 of concrete
Declaration Owner:	Concreto de Morelos S.A. de C.V. km 1.5 Paseo Cuauhnahuac, Colonia Alegria Cuernavaca, Morelos www.grupocomosa.com
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:	23 August 2023
Period of Validity:	5 years; valid until 22 August 2028
EPD Number:	94976086-2428-4aae-9168-32ba362df8fb

TABLE OF CONTENTS

COMPANY DESCRIPTION

GRUPO COMOSA, since 1968, which opened its doors, has produced Ready-Mix Concrete with quality and service to meet the highest standards.

Since its inception, GRUPO COMOSA has successfully participated in the ready-mix concrete industry, which has allowed us to actively participate in the most important infrastructure, housing, and industrial projects in our country.

At GRUPO COMOSA we seek excellence in our products, which is why we have the following standards:

- "Quality Concrete" Certification from the RMX Allies Network,
- ISO 9001:2015 Certification in the Sales Manufacturing and Distribution process of Ready-Mixed Concrete; and·
- Accreditation of the Central Laboratory in NMX-EC-17025-IMNC-2018.

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 Concreto de Morelos S.A. de C.V. 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 Concreto de Morelos S.A. de C.V. 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 Concreto de Morelos S.A. de C.V's license to operate in the community. The intended audience for this LCA report is Concreto de Morelos S.A. de C.V'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 22 concrete mixes manufactured at Concreto de Morelos S.A. de C.V. Polotitlan concrete facility in Polotitlan, Estado de Mexico, México.

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.

All Declared Products

Table 1: **All Declared products considered in this environmental product declaration**

Mix#	Unique name/ID	Short description	Product type	1 day strength, MPa	28 day strength, MPa	H2O to cement ratio
1	FE2200N2AD	21.29 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete		21.29	0.80
2	FE2200N2BB	20.45 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete		20.45	0.81
3	FE1250N2AD	26.49 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete		26.49	0.68
4	FE1250N2BD	25.97 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete		25.97	0.69
5	FE1250N2BB	26 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete		26.00	0.69
6	FE1300N2AD	30.9 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete		30.90	0.59
7	FE1300N2BD	31.4 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete		31.40	0.60
8	FMR040N4AD	41.7 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete		41.70	0.56
9	FMR042N4AD	4.37 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete		4.37	0.55
10	F60310S2FD	22.33 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	22.33		0.49
11	F80350S2AD	31.63 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	31.63		0.40
12	F8l350S2BD	36.77 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	36.77		0.44
13	F80350S2CD	31.19 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	31.19		0.41
14	F80350S1ED	31.05 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	31.05		0.44

15	F8I350S1ED	34.99 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	34.99		0.46
16	F80350S10D	30.42 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	30.42		0.22
17	F8I400S2CD	43.25 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	43.25		0.39
18	F80400S2CD	37.47 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	37.47		0.38
19	F80400S1ED	40.07 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	40.07		0.41
20	F80400S10D	35.32 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	35.32		0.20
21	F80450S1ED	45.87 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	45.87		0.38
22	F8I550S1ED	48.26 MPa 28d strength Ready Mix Concrete	Ready Mix Concrete	48.26		0.35

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 2: **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 3: **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 CPC 40	cement, Portland	1	0	0	0
Water	tap water	1	0	0	0.05
Limestone Gravel	limestone, unprocessed	1	0	0	0.05
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:

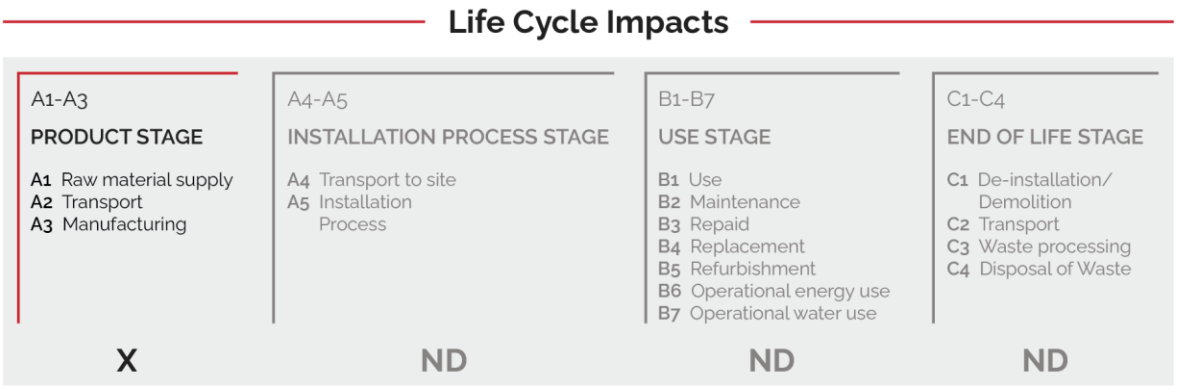

Figure 1: **General life cycle phases for consideration in a construction works system**

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.

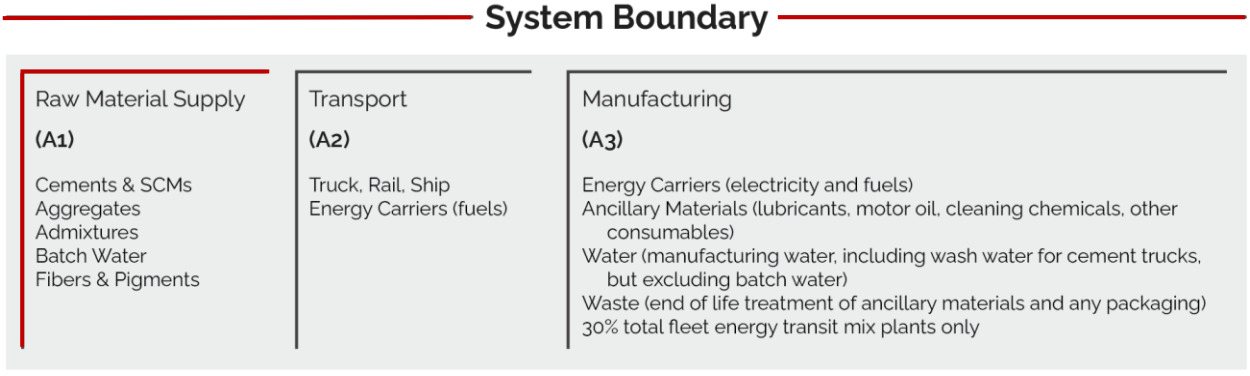

Figure 2: **General system inputs considered in the product system and categorized by modules in scope**

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 Concreto de Morelos S.A de C.V., is located at their Polotitlan facility in Mexico. All operating data is formulated using the actual data from Concreto de Morelos S.A de C.V.'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 Concreto de Morelos S.A de C.V. 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 4: **Inputs required by facility from 2022-01-01 to 2022-12-31 (364 days) to produce 22644.5 m3 of concrete**

Activity	Value	Units
Electricity consumption and on-site generation or off-site contractual procurement (if applicable)		
Gross grid electricity:	30753	kWh
Fuel requirements for machinery		
Diesel	8264	L
Waste generation		
Wash water	2038.005	m3
Hazardous waste	490	kg

Non-hazardous waste	1080000	kg
High-level radioactive waste	NA	kg

No recovered on-site energy occurs at this facility.

Table 5: **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	28	m3	On-Site

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: Electricity consumption values are for COMOSA in calendar year 2022. These values were direct reported from COMOSA records. The unit process "market for electricity, medium voltage/electricity, medium voltage/MX/kWh" was used to represent the Mexico grid electricity used by the concrete 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 COMOSA information. The types of machinery used include generators, pumps to pump concrete to higher elevations, and transportation equipment used for moving materials.

Waste generation: Waste generation values are directly reported from COMOSA 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 COMOSA primary data for the reference year, 2022.

Module A1 material losses: Due to lack of data, default loss factors were assumed.

Direct A3 emissions accounting: Direct emissions are modeled using fuel and technology appropriate ecoinvent activities. See LCI input tables for details.

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 COMOSA reporting for the reference year 2022.

Product transport requirements: The diesel fuel used by the mixing trucks is direct primary information reported from Concreto de Morelos S.A de C.V. records for the year 2022. The concrete PCR allots 30% of the overall mixing truck total for stage A3 (manfacturing) for mixing the materials.

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 6: **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	Hidalgo	v3.8 in 2021	2	3	2	3	3
Limestone Gravel	limestone quarry operation/limestone, unprocessed/RoW/kg	ecoinvent v3.8	Queretaro	v3.8 in 2021	2	3	2	3	3
Additives	market for chemical, organic/chemical, organic/GLO/kg	ecoinvent v3.8	Multiple States	v3.8 in 2021	2	3	2	3	3
Cement CPC 40	CPC 40	Progam Operator: Labeling Sustainability-EPD ID: e38f688d-1fa5-41b0-a9b1-e5b1422ea654	Estado de México	very good, 3rd party verfied facility-specific EPD dataset	3	3	3	3	3
Sand	sand quarry operation, extraction from river bed/sand/BR/kg; Note: modifications made (see ecoinvent activity changes table)	ecoinvent v3.8	Querétaro	v3.8 in 2021	2	3	1	3	3

Table 7: **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	market for transport, freight, lorry 7.5-16	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3

transport via Truck	metric ton, EURO6/transport, freight, lorry 7.5-16 metric ton, EURO6/RoW/tkm								
Cement CPC 40- 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
Limestone 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
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 8: **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

Table 9: **All technosphere input changes made to any ecoinvent activities used in the system model**

ID	Product	Update Type	Activity name to Change	Name_inputActivity	Value	Units	Explanation
1	Gravel	Remove	limestone quarry operation/limestone,	market group for electricity, medium voltage/electricity,	0.00274	kWh	Regarding activity 'limestone quarry operation/limestone, unprocessed/RoW/

			unprocessed/RoW/kg	medium voltage/GLO/kWh			kg', the input 'market group for electricity, medium voltage/electricity, medium voltage/GLO/kWh', was removed assuming 2.74E-3 kWh
2	Gravel	Add	limestone quarry operation/limestone, unprocessed/RoW/kg	market for electricity, medium voltage/electricity, medium voltage/MX/kWh	0.00274	kWh	Regarding activity 'limestone quarry operation/limestone, unprocessed/RoW/kg', the input 'market for electricity, medium voltage/electricity, medium voltage/MX/kWh', was added assuming 2.74E-3 kWh
3	Sand	Remove	sand quarry operation, extraction from river bed/sand/BR/kg	market group for electricity, medium voltage/electricity, medium voltage/BR/kWh	0.00013	kWh	Regarding activity 'sand quarry operation, extraction from river bed/sand/BR/kg', the input 'market group for electricity, medium voltage/electricity, medium voltage/BR/kWh', was removed assuming 1.30E-4 kWh
4	Sand	Add	sand quarry operation, extraction from river bed/sand/BR/kg	market for electricity, medium voltage/electricity, medium voltage/MX/kWh	0.00013	kWh	Regarding activity 'sand quarry operation, extraction from river bed/sand/BR/kg', the input 'market for electricity, medium voltage/electricity, medium voltage/MX/kWh', was added assuming 1.30E-4 kWh

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 Ready mix Concrete 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 2022-01-01 to 2022-12-31.
- 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 10: **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 11: **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 (C2H4) 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 produce 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 ready mix concrete facility on a per 1m3 of concrete basis.

All Declared Products

Table 12: **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	259	0.365	277	1.02E-05	6.09	0.000965	875
Maximum	693	0.832	647	1.52E-05	16.5	0.00229	1400
Mean	460.54	0.5817	448.1	1.25E-05	10.90	0.001581	1116.22
Median	511.5	0.6365	489.5	1.27E-05	12.1	0.001725	1135
FE2200N2AD	259	0.365	277	1.04e-05	6.09	0.000965	875
FE2200N2BB	270	0.377	286	1.06e-05	6.35	0.001	894
FE1250N2AD	303	0.412	313	1.07e-05	7.14	0.0011	919
FE1250N2BD	314	0.424	324	1.1e-05	7.4	0.00114	948
FE1250N2BB	314	0.424	324	1.1e-05	7.4	0.00114	948
FE1300N2AD	347	0.46	352	1.13e-05	8.19	0.00124	984
FE1300N2BD	358	0.472	361	1.15e-05	8.45	0.00127	1000
FMR040N4AD	352	0.464	350	1.02e-05	8.31	0.00122	898
FMR042N4AD	363	0.476	359	1.03e-05	8.57	0.00126	911
F60310S2FD	419	0.537	413	1.21e-05	9.9	0.00145	1060
F80350S2AD	528	0.654	503	1.28e-05	12.5	0.00178	1160
F8I350S2BD	594	0.724	557	1.28e-05	14.1	0.00196	1190
F80350S2CD	495	0.619	476	1.26e-05	11.7	0.00167	1110
F80350S1ED	534	0.662	514	1.39e-05	12.7	0.00183	1260
F8I350S1ED	539	0.667	516	1.36e-05	12.8	0.00182	1220
F80350S10D	536	0.664	520	1.52e-05	12.7	0.00185	1340
F8I400S2CD	605	0.736	568	1.34e-05	14.4	0.002	1230
F80400S2CD	539	0.666	513	1.3e-05	12.8	0.0018	1160
F80400S1ED	578	0.709	551	1.41e-05	13.7	0.00196	1310

F80400S10D	569	0.699	546	1.5e-05	13.5	0.00194	1340
F80450S1ED	623	0.756	589	1.47e-05	14.8	0.0021	1400
F8I550S1ED	693	0.832	647	1.51e-05	16.5	0.00229	1400

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	979	49.7	927	26.1	0.00338	5.78	75.9	0.00198	0.108	9e-05	0.0216	47.7
Maximum	1620	117	1500	44.3	0.00894	11.3	90.5	0.00295	0.247	9e-05	0.0216	47.7
Mean	1274.95	81.35	1189.86	34.44	0.005958	8.36	82.87	0.002428	0.195	9e-05	0.0216	47.7
Median	1300	88.45	1215	35.3	0.006575	8.71	83.25	0.00245	0.2	9e-05	0.0216	47.7
FE2200N2AD	979	49.7	927	26.1	0.00338	9.28	77	0.00205	0.189	9e-05	0.0216	47.7
FE2200N2BB	1000	51.5	946	26.6	0.00355	9.44	77.6	0.00208	0.2	9e-05	0.0216	47.7
FE1250N2AD	1040	56.2	978	27.6	0.00405	8.79	77.9	0.0021	0.189	9e-05	0.0216	47.7
FE1250N2BD	1070	58.6	1010	28.6	0.00413	9.2	78.8	0.00216	0.2	9e-05	0.0216	47.7
FE1250N2BB	1070	59	1010	28.6	0.00403	9.2	78.8	0.00216	0.2	9e-05	0.0216	47.7
FE1300N2AD	1110	63	1040	29.8	0.0045	8.85	79.6	0.00221	0.189	9e-05	0.0216	47.7
FE1300N2BD	1130	64.7	1060	30.5	0.00484	9.01	80.1	0.00225	0.2	9e-05	0.0216	47.7
FMR040N4AD	1020	62.2	955	27.4	0.00445	6.33	75.9	0.00198	0.184	9e-05	0.0216	47.7
FMR042N4AD	1040	64.1	971	27.7	0.00487	6.26	76.2	0.002	0.184	9e-05	0.0216	47.7
F60310S2FD	1210	75.8	1130	32.7	0.00548	8.59	81.8	0.00236	0.189	9e-05	0.0216	47.7
F80350S2AD	1330	90.6	1240	36.1	0.00679	7.02	83.4	0.00246	0.2	9e-05	0.0216	47.7
F8I350S2BD	1380	99.9	1280	37.7	0.00758	5.78	83.5	0.00246	0.247	9e-05	0.0216	47.7
F80350S2CD	1270	86.3	1190	34.5	0.00636	7.66	83.1	0.00244	0.189	9e-05	0.0216	47.7
F80350S1ED	1450	94.8	1350	39.2	0.00696	9.21	86.7	0.00268	0.22	9e-05	0.0216	47.7
F8I350S1ED	1400	94.6	1300	38	0.00693	8.88	86.2	0.00263	0.231	9e-05	0.0216	47.7
F80350S10D	1520	95.5	1430	41.2	0.00694	11.3	90.5	0.00295	0.108	9e-05	0.0216	47.7

F8I400S2CD	1430	102	1310	38.9	0.00778	6.59	85.3	0.00258	0.22	9e-05	0.0216	47.7
F80400S2CD	1330	92.5	1240	36.2	0.00708	7.34	84.2	0.00251	0.189	9e-05	0.0216	47.7
F80400S1ED	1500	102	1390	40.6	0.00736	8.63	87.4	0.00272	0.22	9e-05	0.0216	47.7
F80400S10D	1540	99.9	1430	41.7	0.0072	10.2	90	0.00291	0.108	9e-05	0.0216	47.7
F80450S1ED	1610	110	1500	43.8	0.00787	8.39	88.8	0.00282	0.22	9e-05	0.0216	47.7
F8I550S1ED	1620	117	1490	44.3	0.00894	8.04	90.5	0.00291	0.231	9e-05	0.0216	47.7

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.