Environmental Product Declaration

Environmental Product Declaration for various ready mix concrete products produced by Holcim México Operaciones S.A. de C.V. at their Celaya facility in Guanajuato, México

ADMINISTRATIVE INFORMATION

International Certified Environmental Product Declaration

Declared Product:	This Environmental Product Declaration (EPD) covers concrete products produced by Holcim México Operaciones S.A. de C.V.. Declared unit: 1 m3 of concrete
Declaration Owner:	Holcim México Operaciones S.A. de C.V. Av. Prolongación Vasco de Quiroga #4800 Torre II Ofic. 101 Piso 1, Santa Fe Cuajimalpa de Morelos Ciudad de México, México www.holcim.com.mx
Program Operator:	Labeling Sustainability 11670 W Sunset Blvd. Los Angeles, CA www.labelinsustainability.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:	13 July 2023
Period of Validity:	5 years; valid until 12 July 2028
EPD Number:	d3e11339-5390-49c9-9631-249e78f8bd39

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COMPANY DESCRIPTION

Holcim Mexico produces and markets cement, ready-mix concrete, and other products and services for construction. The company has a nationwide presence through 7 cement plants with a current installed capacity to produce 12.6 million tons per year, 23 cement distribution centers, two maritime terminals, 1 Corporate Office, plus 35 ready-mix concrete plants, seven platforms, and a Geocycle transfer center, 26 commercial partners with more than 90 ready-mix concrete plants, more than 500 mixing pots, one aggregates plant and a Technological Innovation Center for Construction (CITEC).

Sustainable Development is an integral part of Lafarge Holcim's strategy around the world. Holcim Mexico has a clear vision of the future it wants for our country, which contributes to its development. Holcim Mexico's main objective is to create value. Creating value ensures long-term business success in covering the triple bottom line (i.e., social, economic, environmental values). Finally, good operating performance and a solid return on invested capital go hand in hand with sustainable development.

Holcim continues to invest in research and development. They have the Innovation and Development Center, located in Lyon (France), with satellite locations in various regions developing a comprehensive portfolio of innovators and sustainable solutions. These include different categories: inclusive business models, water management solutions, urban mining solutions (recycled aggregates), waste treatment services, energy-efficient solutions (insulating building materials), resource-efficient solutions (high recycled content, bags soluble cement), and low CO2 building materials.

Holcim operates with the belief that they can gain an advantage by developing knowledge and brand equity in the green building segment.

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 México Operaciones 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 Holcim México Operaciones 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 Holcim México Operaciones S.A. de C.V.'s license to operate in the community. The intended audience for this LCA report is Holcim México Operaciones 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 37 concrete mixes manufactured at the Holcim Mexico Operaciones S.A. de C.V. Celaya concrete facility in Guanajuato, 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 ready mix concrete products considered in this EPD along with key performance parameters.

Mix designs: 0 to 15 MPa

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	3740NB2014	0.04 MPa 28d strength Ready mix concrete	Ready mix concrete	0.04	0.45
2	24005NB0514	0.49 MPa 28d strength mortars and fillers	mortars and fillers	0.49	15.03
3	24007NB0518	0.69 MPa 28d strength mortars and fillers	mortars and fillers	0.69	6.01
4	24010NB0514	0.98 MPa 28d strength mortars and fillers	mortars and fillers	0.98	5.25
5	24015NB0518	1.47 MPa 28d strength mortars and fillers	mortars and fillers	1.47	3.96
6	24020NB0514	1.96 MPa 28d strength mortars and fillers	mortars and fillers	1.96	3.11
7	24025NB0518	2.45 MPa 28d strength mortars and fillers	mortars and fillers	2.45	2.85
8	24030NB0514	2.94 MPa 28d strength mortars and fillers	mortars and fillers	2.94	2.23
9	39035ND2006	3.43 MPa 28d strength Ready mix concrete	Ready mix concrete	3.43	0.81

10	24035NB0518	3.43 MPa 28d strength mortars and fillers	mortars and fillers	3.43	2.16
11	39036ND2006	3.53 MPa 28d strength Ready mix concrete	Ready mix concrete	3.53	0.79
12	39038ND2006	3.73 MPa 28d strength Ready mix concrete	Ready mix concrete	3.73	0.76
13	77040ND2010	3.92 MPa 28d strength Ready mix concrete	Ready mix concrete	3.92	0.85
14	24040NB0514	3.92 MPa 28d strength mortars and fillers	mortars and fillers	3.92	1.78
15	77042ND2010	4.12 MPa 28d strength Ready mix concrete	Ready mix concrete	4.12	0.82
16	39045ND2006	4.41 MPa 28d strength Ready mix concrete	Ready mix concrete	4.41	0.67
17	77048ND2010	4.71 MPa 28d strength Ready mix concrete	Ready mix concrete	4.71	0.75
18	39050NB4012	4.9 MPa 28d strength Ready mix concrete	Ready mix concrete	4.90	0.67
19	24050NB0518	4.9 MPa 28d strength mortars and fillers	mortars and fillers	4.90	1.75
20	70100NB2014	9.81 MPa 28d strength Ready mix concrete	Ready mix concrete	9.81	1.32
21	73100NB0514	9.81 MPa 28d strength mortars and fillers	mortars and fillers	9.81	1.35
22	70150ND2010	14.71 MPa 28d strength Ready mix concrete	Ready mix concrete	14.71	1.05
23	60150ND4010	14.71 MPa 28d strength special concrete	special concrete	14.71	0.67
24	73150NB0514	14.71 MPa 28d strength mortars and fillers	mortars and fillers	14.71	1.15

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
25	70175NB2014	17.16 MPa 28d strength Ready mix concrete	Ready mix concrete	17.16	1.22
26	70200NB2018	19.61 MPa 28d strength Ready mix concrete	Ready mix concrete	19.61	1.04
27	60200ND1000	19.61 MPa 28d strength special concrete	special concrete	19.61	0.37
25	70175NB2014	17.16 MPa 28d strength Ready mix concrete	Ready mix concrete	17.16	1.22

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
28	70210NB2014	20.59 MPa 28d strength Ready mix concrete	Ready mix concrete	20.59	1.11
29	70250ND2014	24.52 MPa 28d strength Ready mix concrete	Ready mix concrete	24.52	0.91
30	60250NB2014	24.52 MPa 28d strength special concrete	special concrete	24.52	0.67

Mix designs: 26 to 30 MPa

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

Mix#	Unique name/ID	Short description	Product type	28 day strength, MPa	H2O to cement ratio
31	70280NB2014	27.46 MPa 28d strength Ready mix concrete	Ready mix concrete	27.46	0.91
32	70300ND2014	29.42 MPa 28d strength Ready mix concrete	Ready mix concrete	29.42	0.82
33	60300ND2014	29.42 MPa 28d strength special concrete	special concrete	29.42	0.52

Mix designs: 31 to 35 MPa

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

Mix#	Unique name/ID	Short description	Product type	28 day strength, MPa	H2O to cement ratio
34	70320ND2010	31.38 MPa 28d strength Ready mix concrete	Ready mix concrete	31.38	0.83
35	70350NB2014	34.32 MPa 28d strength Ready mix concrete	Ready mix concrete	34.32	0.74

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
36	70360ND2014	35.3 MPa 28d strength Ready mix concrete	Ready mix concrete	35.30	0.74
37	70400ND2010	39.23 MPa 28d strength Ready mix concrete	Ready mix concrete	39.23	0.68

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
Mineral Additions (River sand and Gravel)	30-60.00
Others	0.01-5.00
Total	100.00

SYSTEM BOUNDARIES

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

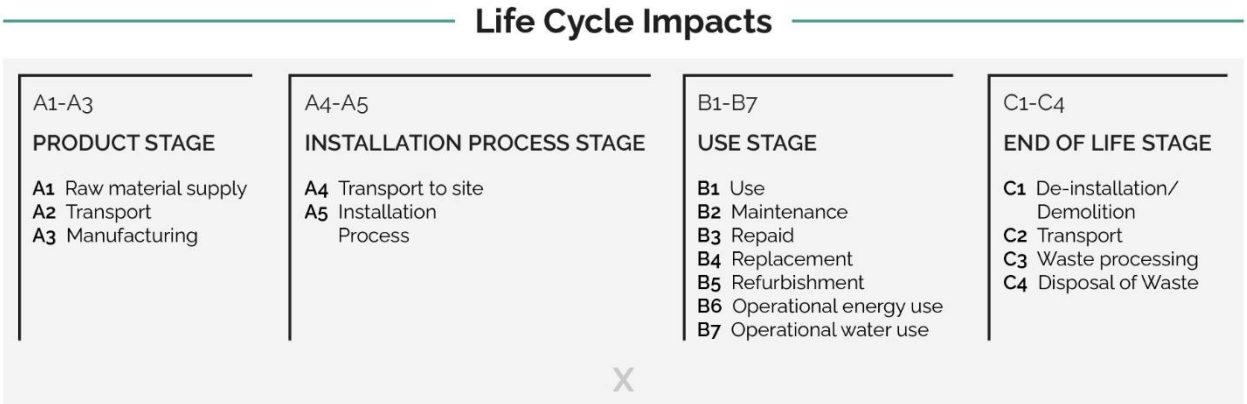

Figure 1: **General life cycle phases for consideration in a construction works system**

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 ready mix concrete products and is not necessarily exhaustive.

System Boundary

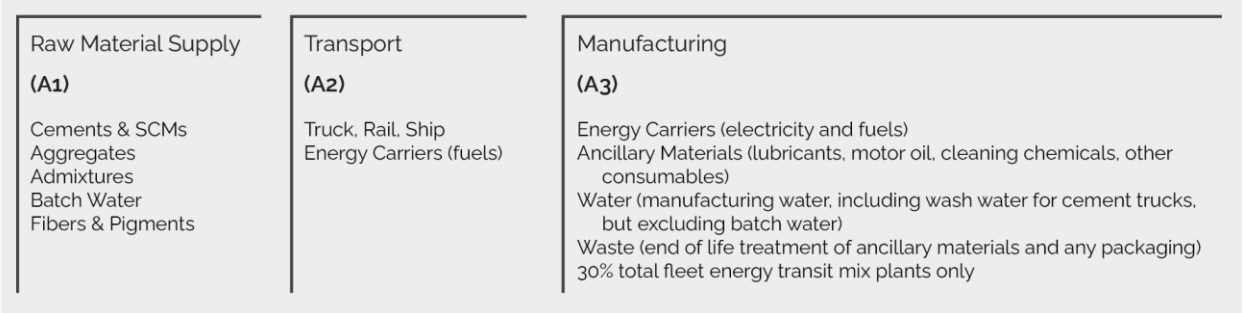

Figure 2: **General system inputs considered in the product system and categorized by modules in scope**

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 México Operaciones S.A. de C.V., is located at their Planta Celaya facility in México. All operating data is formulated using the actual data from Holcim México Operaciones 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 Holcim México Operaciones 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

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 Holcim Mexico in calendar year 2022. These values were direct reported from Holcim 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 Holcim 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 Holcim operations for both bulk waste and hazardous waste. No High-level radioactive waste is generated on-site at this facility. Wash water values are direct reported water use from Holcim México for 2022.

Recovery 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 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 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 México records for the year 2022. The concrete PCR allots 30% of the overall mixing truck total for stage A3 (manufacturing) 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 8: **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
Andesite sand	basalt quarry operation/basalt/RoW/kg; Note: modifications made (see ecoinvent activity changes table)	ecoinvent v3.8	Querétaro	v3.8 in 2021	2	3	1	3	3
Water	tap water production, conventional with biological treatment/tap water/RoW/kg	ecoinvent v3.8	Celaya	v3.8 in 2021	2	3	1	3	3
Gravel	limestone quarry operation/limestone, unprocessed/RoW/kg ; Note: modifications made (see ecoinvent activity changes table)	ecoinvent v3.8	Juventino Rosas, Juventino Rosas, Cadereyta	v3.8 in 2021	2	3	1	3	3
Additives	market for chemical, organic/chemical, organic/GLO/kg	ecoinvent v3.8	Guanajuato	v3.8 in 2021	2	3	1	3	3
Cement (CPC 40) - SUPPLIER: Cementos Apaxco S.A. de C.V. (Apaxco Plant)	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	NA	3	3	3
River sand	sand quarry operation, extraction from river bed/sand/BR/kg; Note: modifications	ecoinvent v3.8	Guanajuato	v3.8 in 2021	2	3	1	3	3

	made (see ecoinvent activity changes table)								

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).

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

LIMITATIONS

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

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

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

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.

Mix designs: 0 to 15 MPa

Table 9: **Total life cycle (across modules in scope) impact results for Mix designs: 0 to 15MPa, 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	37.8	0.12	90.7	7.82e-06	0.792	0.000272	663
Maximum	716	1.11	2490	0.00024	14.4	0.0232	66600
Mean	300	0.416	400	2.28e-05	6.75	0.002	3890
Median	313	0.418	333	1.42e-05	7.33	0.00116	1200
3740NB2014	612	0.745	601	1.98e-05	14.4	0.00213	1760
24005NB0514	37.8	0.12	90.7	7.82e-06	0.792	0.000272	663
24007NB0518	89.3	0.175	134	7.92e-06	2.02	0.000433	710
24010NB0514	81.9	0.168	129	8.55e-06	1.84	0.000413	733
24015NB0518	128	0.217	167	8.53e-06	2.94	0.000555	769
24020NB0514	126	0.216	168	9.29e-06	2.9	0.000554	805
24025NB0518	172	0.265	206	9.21e-06	3.99	0.000693	835
24030NB0514	170	0.264	206	9.96e-06	3.95	0.000692	871
39035ND2006	338	0.45	368	1.65e-05	7.91	0.00131	1440
24035NB0518	222	0.319	249	9.95e-06	5.17	0.000848	909
39036ND2006	345	0.458	374	1.66e-05	8.07	0.00133	1450
39038ND2006	358	0.472	385	1.68e-05	8.4	0.00137	1470
77040ND2010	368	0.482	389	1.61e-05	8.63	0.00137	1390
24040NB0514	716	1.11	2490	0.00024	10.6	0.0232	66600
77042ND2010	381	0.496	401	1.63e-05	8.95	0.00141	1400
39045ND2006	405	0.523	426	1.75e-05	9.52	0.00152	1540
77048ND2010	421	0.538	435	1.68e-05	9.89	0.00153	1450
39050NB4012	408	0.526	426	1.73e-05	9.58	0.00151	1490
24050NB0518	271	0.373	291	1.07e-05	6.35	0.001	979
70100NB2014	255	0.359	291	1.4e-05	5.95	0.00101	1200
73100NB0514	292	0.396	314	1.21e-05	6.84	0.00108	1070
70150ND2010	281	0.388	311	1.45e-05	6.58	0.00107	1200
60150ND4010	378	0.493	400	1.69e-05	8.86	0.00141	1450
73150NB0514	334	0.441	352	1.3e-05	7.82	0.00123	1190

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	719	0	704	19.6	0.000713	0.629	69.9	0.00155	0.231	1.26e-05	0.0342	46.3
Maximum	73600	1200	72000	1800	0.034	8.01	303	0.0277	0.44	1.26e-05	0.0342	46.3
Mean	4310	98	4190	109	0.00511	1.68	100	0.0036	0.323	1.26e-05	0.0342	46.3
Median	1340	56	1280	36.3	0.00425	0.776	96.2	0.00273	0.318	1.26e-05	0.0342	46.3
3740NB2014	1990	101	1870	53.5	0.00834	0.995	116	0.00375	0.254	1.26e-05	0.0342	46.3
24005NB0514	719	0	704	19.6	0.000713	3.12	69.9	0.00155	0.357	1.26e-05	0.0342	46.3
24007NB0518	781	22	754	21.6	0.00139	0.629	69.9	0.00157	0.44	1.26e-05	0.0342	46.3
24010NB0514	798	21	777	21.9	0.00129	3.13	72.3	0.00167	0.345	1.26e-05	0.0342	46.3
24015NB0518	848	27.8	820	23.6	0.00192	0.667	72	0.00167	0.435	1.26e-05	0.0342	46.3
24020NB0514	887	28.1	854	24.3	0.00186	3.14	74.7	0.00181	0.335	1.26e-05	0.0342	46.3
24025NB0518	928	35.7	891	25.6	0.00244	0.711	74.2	0.00179	0.432	1.26e-05	0.0342	46.3
24030NB0514	965	34.9	928	26.5	0.0023	3.14	77	0.00192	0.334	1.26e-05	0.0342	46.3
39035ND2006	1600	57	1540	42.5	0.0046	0.706	105	0.00314	0.249	1.26e-05	0.0342	46.3
24035NB0518	1010	43.8	971	28	0.00307	0.763	76.8	0.00192	0.43	1.26e-05	0.0342	46.3
39036ND2006	1610	58.7	1540	42.9	0.00468	0.712	105	0.00317	0.248	1.26e-05	0.0342	46.3
39038ND2006	1620	61.1	1560	43.7	0.00489	0.725	106	0.0032	0.247	1.26e-05	0.0342	46.3
77040ND2010	1550	63.1	1480	41.5	0.005	0.772	103	0.00307	0.287	1.26e-05	0.0342	46.3
24040NB0514	73600	1200	72000	1800	0.034	8.01	303	0.0277	0.341	1.26e-05	0.0342	46.3
77042ND2010	1550	65	1490	42	0.00501	0.785	104	0.0031	0.287	1.26e-05	0.0342	46.3
39045ND2006	1710	68.3	1640	45.8	0.00552	0.774	108	0.00331	0.247	1.26e-05	0.0342	46.3
77048ND2010	1630	70.4	1550	43.7	0.00555	0.828	106	0.00319	0.289	1.26e-05	0.0342	46.3
39050NB4012	1660	65.8	1590	44.5	0.00537	0.777	108	0.00329	0.251	1.26e-05	0.0342	46.3

24050NB0518	1100	51.5	1050	30.4	0.00371	0.817	79.1	0.00204	0.431	1.26e-05	0.0342	46.3
70100NB2014	1320	45.7	1280	35.7	0.00351	0.67	95.1	0.00269	0.301	1.26e-05	0.0342	46.3
73100NB0514	1200	55.1	1140	33.3	0.004	0.775	83.5	0.00234	0.357	1.26e-05	0.0342	46.3
70150ND2010	1340	50	1280	35.4	0.0038	6.23	97.3	0.00277	0.268	1.26e-05	0.0342	46.3
60150ND4010	1620	63.9	1550	43.4	0.00511	0.725	107	0.00323	0.231	1.26e-05	0.0342	46.3
73150NB0514	1330	62.5	1270	36.9	0.0045	0.816	86	0.00249	0.35	1.26e-05	0.0342	46.3

Mix designs: 15 to 20 MPa

Table 10: **Total life cycle (across modules in scope) impact results for Mix designs: 15 to 20MPa, 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	271	0.377	304	1.42e-05	6.33	0.00106	1210
Maximum	399	0.516	413	1.62e-05	9.4	0.00142	1300
Mean	328	0.439	352	1.5e-05	7.7	0.00122	1260
Median	314	0.423	339	1.46e-05	7.37	0.00119	1260
70175NB2014	271	0.377	304	1.42e-05	6.33	0.00106	1210
70200NB2018	314	0.423	339	1.46e-05	7.37	0.00119	1260
60200ND1000	399	0.516	413	1.62e-05	9.4	0.00142	1300

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	1350	47.3	1290	36.1	0.00382	0.624	96	0.00272	0.136	1.26e-05	0.0342	46.3
Maximum	1450	61.9	1380	38.8	0.00526	5.18	108	0.00315	0.298	1.26e-05	0.0342	46.3
Mean	1400	54.7	1340	37.4	0.00445	2.16	100	0.00288	0.244	1.26e-05	0.0342	46.3
Median	1410	55	1350	37.3	0.00428	0.682	97	0.00277	0.297	1.26e-05	0.0342	46.3
70175NB2014	1350	47.3	1290	36.1	0.00382	0.682	96	0.00272	0.298	1.26e-05	0.0342	46.3
70200NB2018	1410	55	1350	37.3	0.00428	5.18	97	0.00277	0.297	1.26e-05	0.0342	46.3

60200ND1000	1450	61.9	1380	38.8	0.00526	0.624	108	0.00315	0.136	1.26e-05	0.0342	46.3

Mix designs: 21 to 25 MPa

Table 11: **Total life cycle (across modules in scope) impact results for Mix designs: 21 to 25MPa, 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	293	0.4	323	1.46e-05	6.85	0.00113	1250
Maximum	382	0.497	403	1.67e-05	8.96	0.00142	1440
Mean	338	0.449	363	1.55e-05	7.92	0.00127	1340
Median	339	0.451	362	1.53e-05	7.96	0.00127	1330
70210NB2014	293	0.4	323	1.46e-05	6.85	0.00113	1250
70250ND2014	339	0.451	362	1.53e-05	7.96	0.00127	1330
60250NB2014	382	0.497	403	1.67e-05	8.96	0.00142	1440

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	1390	52.2	1330	37.3	0.00395	0.702	97.3	0.00279	0.234	1.26e-05	0.0342	46.3
Maximum	1610	64.5	1550	43.2	0.00517	4.82	106	0.00319	0.294	1.26e-05	0.0342	46.3
Mean	1490	59	1430	39.9	0.00455	2.09	101	0.00296	0.27	1.26e-05	0.0342	46.3
Median	1480	60.2	1410	39.3	0.00452	0.734	99.6	0.0029	0.282	1.26e-05	0.0342	46.3
70210NB2014	1390	52.2	1330	37.3	0.00395	0.702	97.3	0.00279	0.294	1.26e-05	0.0342	46.3
70250ND2014	1480	60.2	1410	39.3	0.00452	4.82	99.6	0.0029	0.282	1.26e-05	0.0342	46.3
60250NB2014	1610	64.5	1550	43.2	0.00517	0.734	106	0.00319	0.234	1.26e-05	0.0342	46.3

Mix designs: 26 to 30 MPa

Table 12: **Total life cycle (across modules in scope) impact results for Mix designs: 26 to 30MPa, 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	350	0.462	372	1.54e-05	8.21	0.00131	1330
Maximum	587	0.718	580	1.94e-05	13.8	0.00208	1810
Mean	439	0.558	450	1.69e-05	10.3	0.00159	1510
Median	379	0.493	397	1.59e-05	8.9	0.00139	1390
70280NB2014	350	0.462	372	1.54e-05	8.21	0.00131	1330
70300ND2014	379	0.493	397	1.59e-05	8.9	0.00139	1390
60300ND2014	587	0.718	580	1.94e-05	13.8	0.00208	1810

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	1480	59.7	1420	40	0.0047	0.759	100	0.00294	0.281	1.26e-05	0.0342	46.3
Maximum	2040	100	1940	54.2	0.00771	4.62	112	0.00362	0.292	1.26e-05	0.0342	46.3
Mean	1690	75.1	1610	45.2	0.00582	3.33	105	0.00319	0.286	1.26e-05	0.0342	46.3
Median	1550	65.7	1480	41.3	0.00504	4.62	102	0.00301	0.284	1.26e-05	0.0342	46.3
70280NB2014	1480	59.7	1420	40	0.0047	0.759	100	0.00294	0.292	1.26e-05	0.0342	46.3
70300ND2014	1550	65.7	1480	41.3	0.00504	4.62	102	0.00301	0.284	1.26e-05	0.0342	46.3
60300ND2014	2040	100	1940	54.2	0.00771	4.62	112	0.00362	0.281	1.26e-05	0.0342	46.3

Mix designs: 31 to 35 MPa

Table 13: **Total life cycle (across modules in scope) impact results for Mix designs: 31 to 35MPa, 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	378	0.492	397	1.61e-05	8.87	0.0014	1390
Maximum	424	0.542	436	1.64e-05	9.99	0.00153	1440
Mean	401	0.517	416	1.62e-05	9.43	0.00146	1420
Median	401	0.517	416	1.62e-05	9.43	0.00146	1420
70320ND2010	378	0.492	397	1.61e-05	8.87	0.0014	1390
70350NB2014	424	0.542	436	1.64e-05	9.99	0.00153	1440

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	1550	63.2	1480	41.7	0.00518	0.782	103	0.00307	0.286	1.26e-05	0.0342	46.3
Maximum	1620	73	1540	43.1	0.00555	4.64	103	0.0031	0.29	1.26e-05	0.0342	46.3
Mean	1580	68.1	1510	42.4	0.00536	2.71	103	0.00308	0.288	1.26e-05	0.0342	46.3
Median	1580	68.1	1510	42.4	0.00536	2.71	103	0.00308	0.288	1.26e-05	0.0342	46.3
70320ND2010	1550	63.2	1480	41.7	0.00518	0.782	103	0.00307	0.286	1.26e-05	0.0342	46.3
70350NB2014	1620	73	1540	43.1	0.00555	4.64	103	0.0031	0.29	1.26e-05	0.0342	46.3

Mix designs: 36 to 40 MPa

Table 14: **Total life cycle (across modules in scope) impact results for Mix designs: 36 to 40MPa, 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	432	0.55	445	1.69e-05	10.1	0.00158	1500
Maximum	471	0.593	479	1.75e-05	11.1	0.0017	1560
Mean	452	0.572	462	1.72e-05	10.6	0.00164	1530
Median	452	0.572	462	1.72e-05	10.6	0.00164	1530
70360ND2014	432	0.55	445	1.69e-05	10.1	0.00158	1500
70400ND2010	471	0.593	479	1.75e-05	11.1	0.0017	1560

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	1680	73.8	1610	45.3	0.00568	0.849	105	0.00321	0.294	1.26e-05	0.0342	46.3
Maximum	1760	78.9	1670	47.2	0.00623	0.891	107	0.00332	0.294	1.26e-05	0.0342	46.3
Mean	1720	76.4	1640	46.2	0.00596	0.87	106	0.00326	0.294	1.26e-05	0.0342	46.3
Median	1720	76.4	1640	46.2	0.00596	0.87	106	0.00326	0.294	1.26e-05	0.0342	46.3
70360ND2014	1680	73.8	1610	45.3	0.00568	0.849	105	0.00321	0.294	1.26e-05	0.0342	46.3
70400ND2010	1760	78.9	1670	47.2	0.00623	0.891	107	0.00332	0.294	1.26e-05	0.0342	46.3

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.