Environmental Product Declaration

Environmental Product Declaration for various ready mix concrete products produced by Holcim Ecuador at their San Eduardo (SED) facility in Guayaquil, Ecuador

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ADMINISTRATIVE INFORMATION

International Certified Environmental Product Declaration

Declared Product:	This Environmental Product Declaration (EPD) covers concrete products produced by Holcim Ecuador. Declared unit: 1 m3 of concrete
Declaration Owner:	Holcim Ecuador S/N Av. Barcelona y José Rodríguez Bonin, Edif. El Caimán Piso 2 Guayaquil, Ecuador www.holcim.com.ec
Program Operator:	Labeling Sustainability Address, 11670 W Sunset Blvd. City, State, 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:	14 December 2022
Period of Validity:	5 years; valid until 14 December 2027
EPD Number:	c30f03e3-8768-4e3d-a6c2-aa996cc4bb42

COMPANY DESCRIPTION

Holcim Ecuador is part of the international Holcim group, a leader in innovative and sustainable construction solutions. With more than 100 years of experience in the country producing cement, concrete, aggregates, and solutions for the construction market. As well as its subsidiary company, Geocycle reinforces the commitment to the circular economy through the co-processing of waste. Holcim Ecuador has extensive coverage in the national territory, with an integrated cement plant in Guayaquil, a cement grinding plant in Latacunga, ten fixed concrete plants in Guayaquil, Quito, Cuenca, Manabí, Machala, Quevedo and Ambato, mobile equipment concrete, 2 aggregate plants in Pifo and Daule, the latter being Loma Alta, the first plant with 52% women in its operations.

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 Ecuador 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 Ecuador 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 Ecuador's license to operate in the community. The intended audience for this LCA report is Holcim Ecuador'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 15 concrete mixes manufactured at the Planta San Eduardo Holcim Ecuador concrete facility in Guayaquil, Ecuador.

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.

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

Mix#	Unique name/ID	Short description	Product type	28 day strength, MPa	H2O to cement ratio
1	10016164 03210NS1218001 ALTA FLUIDEZ	21 MPa 28d strength ready mix concrete.	Ready Mix	21.0	0.56
2	10016206 01210NS1910001 ESTRUCTURAL	21 MPa 28d strength ready mix concrete.	Ready Mix	21.0	0.59
3	10016211 01280NS1910001 ESTRUCTURAL	27 MPa 28d strength ready mix concrete.	Ready Mix	27.0	0.53
4	10020371 054.5NS1910001 PAVIMENTO	4.5 MPa 28d strength ready mix concrete.	Ready Mix	4.5	0.44
5	10016216 11420NS19190001 ALTA RESISTENCIA	41 MPa 28d strength ready mix concrete.	Ready Mix	41.0	0.41
6	10046681 01300NS1913001 ESTRUCTURAL	29 MPa 28d strength ready mix concrete.	Ready Mix	29.0	0.50
7	10016140 03240NS1918001 ALTA FLUIDEZ	24 MPa 28d strength ready mix concrete.	Ready Mix	24.0	0.52
8	10016142 03280NS1918001 ALTA FLUIDEZ	27 MPa 28d strength ready mix concrete.	Ready Mix	27.0	0.49
9	10046466 01350NS1913001 ESTRUCTURAL	34 MPa 28d strength ready mix concrete.	Ready Mix	34.0	0.46
10	10067249 23210NS1913001 ECOPACT	21 MPa 28d strength ready mix concrete.	Ready Mix	21.0	0.62
11	10067620 23210NS1220001 ECOPACT	21 MPa 28d strength ready mix concrete.	Ready Mix	21.0	0.58
12	10067785 23240NS1913001 ECOPACT	24 MPa 28d strength ready mix concrete.	Ready Mix	24.0	0.58

13	10067250 23280NS1913001 ECOPACT	27 MPa 28d strength ready mix concrete.	Ready Mix	27.0	0.55
14	10067764 23180NS1913001 ECOPACT	18 MPa 28d strength ready mix concrete.	Ready Mix	18.0	0.65
15	10067780 23210NS1213001 ECOPACT	21 MPa 28d strength ready mix concrete.	Ready Mix	21.0	0.61

READY MIX CONCRETE DESIGN COMPOSITION

The following figures provide mass breakdown (kg per functional unit) of the material composition of each ready mix design considered. Please note that the breakdown has been randomly altered 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
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 (ND= Not Defined)

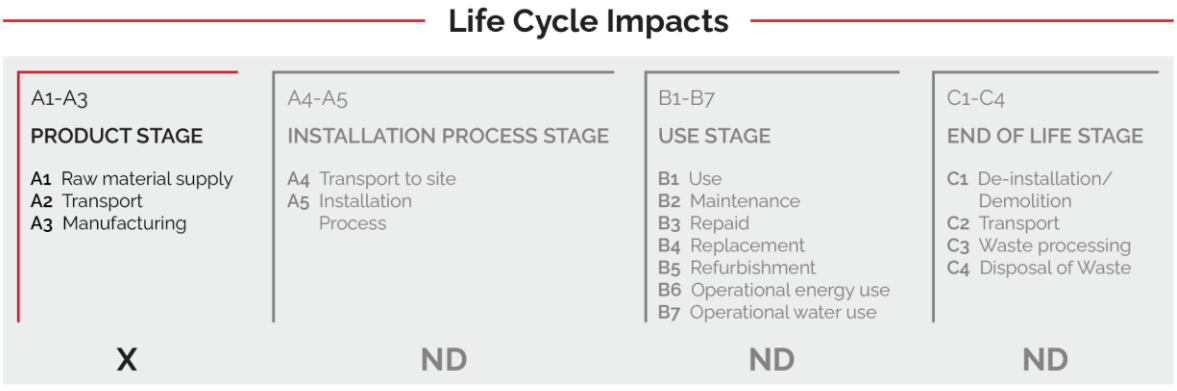

Figure 1: **General life cycle phases for consideration in a construction works system**

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.

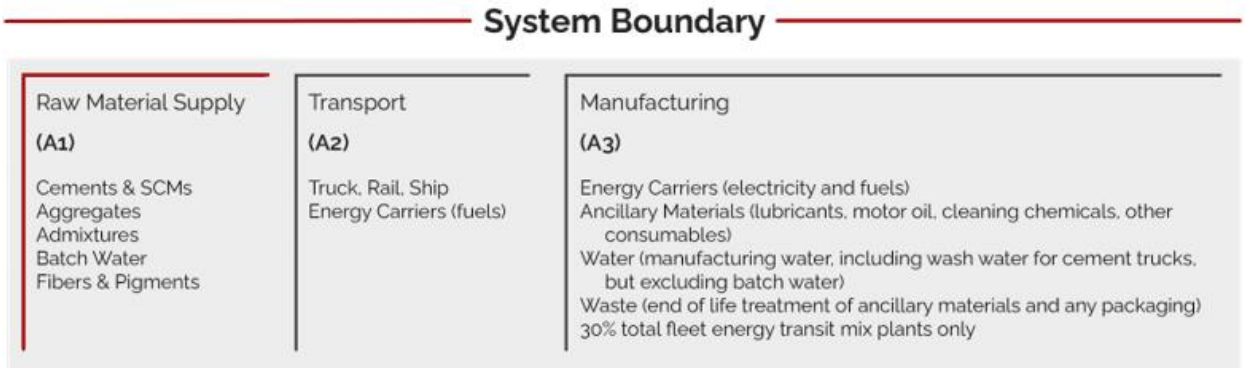

Figure 2: **General system inputs considered in the product system and categorized by modules in scope**

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 Ecuador, is located at their Planta San Eduardo facility in Ecuador. All operating data is formulated using the actual data from Holcim Ecuador'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 Ecuador 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 Ecuador in calendar year 2021. These values were direct reported from Holcim records. The unit process "market for electricity, medium voltage/electricity, medium voltage/EC/kWh" was used to represent the Ecuador grid electricity used by the concrete plant.

Process/space heating: No process and space heating fuels were used at this plant per primary Holcim records.

Fuel required for machinery: Machinery-related fuel requirements were determined from direct Holcim reporting. Diesel fuel is used in generator, pumps for pumping the concrete to high elevations, equipment for moving materials and loaders.

Waste generation: Waste generation values are directly reported from Holcim operations for both bulk waste and hazardous. No High-level radioactive waste is generated on-site at this facility.

Recovered energy: not applicable.

Recycled/reused material/components: The amount of returned concrete is based on Holcim primary data for the reference year, 2021.

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: not applicable.

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. Also included are the values for concrete returned and wash water, measured in kilograms.

Product transport requirements: The diesel fuel used by the mixing trucks is direct primary information reported from Holcim records for the year 2021. Per the reference concrete PCR, 30% of the fuel used is allocated to stage A3 (manufacturing)for material mixing.

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 3: **LCI inputs assumed for module A1 (i.e., raw material supply)**

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	Guayas	v3.8 in 2021	2	3	1	3	3
Limestone sand	limestone production, crushed, for mill/limestone, crushed, for mill/IN/kg; Note: modifications made (see ecoinvent activity changes table)	ecoinvent v3.8	Guayas	v3.8 in 2021	2	3	0	3	3
Additives	market for chemical, organic/chemical, organic/GLO/kg	ecoinvent v3.8	Guayas	v3.8 in 2021	2	3	1	3	3
River sand	sand quarry operation, extraction from river bed/sand/BR/kg; Note: modifications made (see ecoinvent activity changes table)	ecoinvent v3.8	Guayas	v3.8 in 2021	2	3	1	3	3
Gravel	gravel production, crushed/gravel, crushed/BR/kg; Note: modifications made (see ecoinvent activity changes table)	ecoinvent v3.8	Guayas	v3.8 in 2021	2	3	1	3	3
HE RMX Cement	HE Cement	Progam Operator: Labeling Sustainability- EPD ID: e717da92-6eee-4fdb-b7d3-acfac1d3df01	Guayas	29 November 2022	3	3	3	3	3
MH Cement	MH Cement	Progam Operator:	Guayas	29 Nove	3	3	3	3	3

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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 cocnrete 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.

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.

Table 4: **Total life cycle (across modules in scope) impact results for All declared products, assuming the geometric mean point values on a per 1 tonne of concrete basis**

a) Midpoint Impact Categories:

Indicator/LCI Metric	AP	EP	GWP	ODP	PCOP	ADPe	ADPf
Unit	**kg SO2eq**	**kg N**	**kg CO2-Eq**	**kg CFC-11.**	**kg O3eq**	**kg Sbeq**	**kg Sbeq**
Minimum	46.4	0.19	260	1.24e-05	0.694	0.00107	1470
Maximum	64.5	0.207	373	1.53e-05	0.955	0.00159	2010
Mean	54	0.197	306	1.39e-05	0.803	0.00128	1700
Median	53.1	0.196	301	1.38e-05	0.792	0.00124	1680
10016164 03210NS1218001 ALTA FLUIDEZ	52.7	0.195	301	1.34e-05	0.787	0.00124	1650
10016206 01210NS1910001 ESTRUCTURAL	48.4	0.191	268	1.24e-05	0.729	0.00109	1500
10016211 01280NS1910001 ESTRUCTURAL	53.1	0.196	298	1.31e-05	0.795	0.00123	1620
10020371 054.5NS1910001 PAVIMENTO	60.6	0.203	347	1.44e-05	0.903	0.00145	1830
10016216 11420NS19190001 ALTA RESISTENCIA	64.5	0.207	373	1.53e-05	0.955	0.00159	2010
10046681 01300NS1913001 ESTRUCTURAL	55.5	0.198	316	1.37e-05	0.828	0.00131	1710
10016140 03240NS1918001 ALTA FLUIDEZ	52.5	0.195	298	1.33e-05	0.786	0.00123	1630
10016142 03280NS1918001 ALTA FLUIDEZ	56.9	0.2	326	1.4e-05	0.847	0.00136	1770
10046466 01350NS1913001 ESTRUCTURAL	59.6	0.202	343	1.46e-05	0.885	0.00144	1860
10067249 23210NS1913001 ECOPACT	49.1	0.193	277	1.38e-05	0.73	0.00116	1610

10067620 23210NS1220001 ECOPACT	54.1	0.198	307	1.43e-05	0.8	0.00131	1760
10067785 23240NS1913001 ECOPACT	51.2	0.195	290	1.42e-05	0.759	0.00123	1680
10067250 23280NS1913001 ECOPACT	53.5	0.197	303	1.44e-05	0.792	0.00129	1740
10067764 23180NS1913001 ECOPACT	46.4	0.19	260	1.32e-05	0.694	0.00107	1470
10067780 23210NS1213001 ECOPACT	51.2	0.195	285	1.37e-05	0.761	0.00121	1640

b) Inventory Metrics:

Indicator/LCI Metric	**TPE**	**RE**	**NRE**	**NRR**	**RR**	**WDP**	**LFW**	**LFHW**	**bioC**	**CBWC**	**CWWC**	**CHW**	**CNHW**
Unit	**MJ-Eq**	**MJ-Eq**	**MJ-Eq**	**kg**	**kg**	**m3 water-.**	**kg waste**	**kg waste**	**kg**	**m3**	**m3**	**kg**	**kg**
Minimum	1750	189	1560	49.7	0.00111	5.82	108	0.00202	-4.99	0.168	1.3e-05	0.24	84.7
Maximum	2400	243	2140	70.5	0.00016	7.95	114	0.00237	-4.98	0.204	1.3e-05	0.24	84.7
Mean	2020	210	1810	58.7	0.0013	6.73	111	0.00223	-4.98	0.184	1.3e-05	0.24	84.7
Median	2000	205	1790	57.3	0.00128	6.59	111	0.00225	-4.98	0.184	1.3e-05	0.24	84.7
10016164 03210NS1218001 ALTA FLUIDEZ	1960	204	1770	57.3	0.00124	6.87	109	0.00214	-4.98	0.189	1.3e-05	0.24	84.7
10016206 01210NS1910001 ESTRUCTURAL	1790	190	1590	51.1	0.00111	6.94	108	0.00202	-4.98	0.168	1.3e-05	0.24	84.7
10016211 01280NS1910001 ESTRUCTURAL	1930	205	1730	56.6	0.00124	6.46	109	0.0021	-4.98	0.178	1.3e-05	0.24	84.7
10020371 054.5NS1910001 PAVIMENTO	2180	231	1950	64.9	0.00144	5.91	110	0.00225	-4.98	0.18	1.3e-05	0.24	84.7
10016216 11420NS1919001 ALTA	2400	243	2140	70.5	0.00016	5.82	111	0.00237	-4.98	0.184	1.3e-05	0.24	84.7

RESISTENCIA													
10046681 01300NS1913001 ESTRUCTURAL	2030	214	1830	59.9	0.00133	6.44	109	0.00217	-4.98	0.182	1.3e-05	0.24	84.7
10016140 03240NS1918001 ALTA FLUIDEZ	1940	203	1730	56.4	0.00123	7	109	0.00214	-4.98	0.172	1.3e-05	0.24	84.7
10016142 03280NS1918001 ALTA FLUIDEZ	2110	218	1880	61.6	0.00134	6.53	110	0.00222	-4.98	0.183	1.3e-05	0.24	84.7
10046466 01350NS1913001 ESTRUCTURAL	2210	228	1990	65	0.00145	6.62	111	0.00229	-4.98	0.184	1.3e-05	0.24	84.7
10067249 23210NS1913001 ECOPACT	1910	196	1720	54.4	0.00121	7.76	114	0.0023	-4.99	0.187	1.3e-05	0.24	84.7
10067620 23210NS1220001 ECOPACT	2090	212	1880	60.3	0.00135	6.18	113	0.00232	-4.99	0.204	1.3e-05	0.24	84.7
10067785 23240NS1913001 ECOPACT	2000	203	1790	57.2	0.00128	7.65	114	0.00235	-4.99	0.188	1.3e-05	0.24	84.7
10067250 23280NS1913001 ECOPACT	2070	211	1850	59.4	0.00133	6.59	114	0.00234	-4.99	0.189	1.3e-05	0.24	84.7
10067764 23180NS1913001 ECOPACT	1750	189	1560	49.7	0.00112	7.95	113	0.00223	-4.99	0.184	1.3e-05	0.24	84.7
10067780 23210NS1213001 ECOPACT	1950	202	1740	55.7	0.00125	6.2	113	0.00225	-4.99	0.194	1.3e-05	0.24	84.7

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.