Environmental Product Declaration

Mobile Mix Concrete
Servicing the Portland, Oregon Metro Area

This Environmental Product Declaration (EPD) represents the average environmental impact of ready-mix concrete produced and delivered by four leading mobile mix companies servicing the Portland, Oregon area. The EPD was sponsored and underwritten by the City of Portland. This EPD reports the impacts for 1 m^3 of ready mixed concrete mix, meeting the following specifications:

- ASTM C94: Ready-Mixed Concrete
- UNSPSC Code 30111505: Ready Mix Concrete
- CSA A23.1/A23.2: Concrete Materials and Methods of Concrete Construction
- CSI Division 03-30-00: Cast-in-Place Concrete

EPD OWNER

City of Portland, Oregon
OMF Bureau of Revenue and Financial Services
Procurement Services
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EPD PROGRAM OPERATOR

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428

EPD Number: EPD 198

DECLARED UNIT:

1 m^3 of concrete.

DATE OF ISSUE

03/29/2021 **(valid for 5 years until 03/29/2026)**

ENVIRONMENTAL IMPACTS
Declared Unit: *1 m^3 of concrete*

Compressive strength:	**3000 psi**	**3500 psi**	**4000 psi**	**5000 psi**
Global Warming Potential (kg CO2 -eq)	332	354	381	434
Ozone Depletion Potential (kg CFC-11-eq)	5.4E-06	5.8E-06	6.2E-06	7.0E-06
Acidification Potential (kg SO2-eq)	1.5	1.5	1.6	1.8
Eutrophication Potential (kg N-eq)	0.2	0.2	0.3	0.3
Photochemical Ozone Creation Potential (kg O3-eq)	35.5	37.2	39.2	43.6
Abiotic Depletion, non-fossil (kg Sb-eq)	4.99E-05	5.40E-05	5.87E-05	6.79E-05
Abiotic Depletion, fossil (MJ)	1,994	2,092	2,208	2,459
Total Waste Disposed (kg)	1	1	1	1
Consumption of Freshwater (m3)	3.3	3.3	3.3	3.3

Product Components: *natural aggregate (ASTM C33), crushed aggregate (ASTM C33), Portland cement (ASTM C150), batch water (ASTM C1602), admixture (ASTM C494)*

Additional detail and impacts are reported on page six of this EPD

ISO 21930:2017 Sustainability in Building Construction — Environmental Declaration of Building Products: serves as the core PCR

PCR for Concrete, NSF International, February 2019 serves as the sub-category PCR

Sub-category PCR review was conducted by Thomas P. Gloria • Industrial Ecology Consultants

Independent verification of the declaration, according to ISO 14025:2006: ☐ internal ☑ external

Third party verifier: Thomas P. Gloria (t.gloria@industrial-ecology.com) • Industrial Ecology Consultants

For additional explanatory material

Manufacture Representative: Stacey Foreman (Stacey.Foreman@portlandoregon.gov)

LCA & EPD Developer: Climate Earth (support@climateearth.com)

General Information

This cradle to gate Environmental Product Declaration covers the average environmental impact of ready-mix concrete produced and delivered by four leading mobile mix companies servicing the Portland, Oregon Metro Area. The EPD was sponsored and underwritten by the City of Portland. This study was conducted in accordance with North American Product Category Rules (PCR) for concrete (NSF International, 2019), ISO 14040 (ISO 14040, 2006), 14044 (ISO 14044, 2020), and ISO 21930 (ISO 21930, 2017).

Product Description

A mobile concrete mixer is a batch plant mounted on a chassis, usually a truck or trailer, that carries unmixed materials (sand, cement, coarse aggregates, water and any other materials or chemicals needed for more specialty applications) to a job site where it mixes fresh concrete. Mix designs can be changed or altered without moving the machine; the operator can make adjustments at any time as required for the job site. When the job is finished cleanup is an easy process by only washing out the mixer area.

This study reports the average environmental performance of four normal weight concrete mixes produced by mobile mix companies servicing the Portland area to provide concrete used in residential, commercial, and public works applications. At the time of this study, there were seven mobile mixer companies servicing the Portland area. Four of these companies participated in this study (Table 1). The total amount of mobile mix concrete produced by the seven companies is unclear, however it is estimated that the four companies providing data for this study provide >50% of the total annual mobile mix production servicing the Portland area.

Table 1 Description of companies participated in this study

Company	Manufacture Representative	Address
Jake's Mobile Mix Concrete	Jacob Bec	6300 SE 111th Ave, Portland, OR 97266
Portland Water Bureau	Russ Halverson	664 N Tillamook St, Portland, OR 97227
Volume Concrete	Ryan Standley	16051 Oregon Highway 224, Damascus, OR 97089
Tualatin Valley Short Load Concrete	Dean Meyer	11285 SW Tonquin Rd, Sherwood, OR 97140

For this study, four different commonly specified normal weight mixes were selected based on company representative's recommendation. Four different compressive strengths were considered for normal weight concrete: 3,000 psi (20.7 MPa), 3,500 psi (24.1 MPa), 4,000 psi (27.6 MPa) and 5,000 psi (34.5 MPa). These are the most common mix designs that the mobile mixers produce in residential, commercial, and public works applications. Each product considers 28-day strength, water to cementitious materials ratio to meet the specified compressive strength, air-entrainment admixture, water reducing admixture, crushed and natural aggregate and Portland cement.

Table 2 lists the average mix design specifications and raw material quantities considered for each product.

Table 2 Mix design specifications and raw material quantities (weighted average per 1 cubic yard concrete)

Comp. Strength	w/ cm	Slag cement	Air Ent	Cement	Batch water	Water reducer	Non chloride accelerator	Air entrainer	Coarse aggregate	Fine aggregate
(psi)		%	(Y/N)	lb	gal	fl.oz	fl.oz	fl.oz	lb	lb
3000	0.52	0	Y	491	25.4	6.45	0.47	4.01	1,613	1,495
3500	0.49	0	Y	533	25.9	6.45	0.47	4.28	1,613	1,482
4000	0.46	0	Y	579	25.9	6.45	0.47	4.82	1,613	1,458
5000	0.42	0	Y	673	25.6	6.45	0.47	4.82	1,613	1,460

System Boundary

This study is cradle-to-gate covering A1-A3 stages of the life cycle as illustrated in Figure 1.

- A1 - Extraction and processing of raw materials, including fuels used in product production and transport within the manufacturing process (A3).
- A2 – Specific transportation of raw materials (including recycled materials) from extraction site or source to manufacturing site (including any recovered materials from source to be recycled in the process) and including empty backhauls and transportation to interim distribution centers or terminals.
- A3 – Manufacturing of the product, including all energy and materials required and all emissions and wastes produced.

PRODUCTION Stage (*Mandatory*)			CONSTRUCTION Stage		USE Stage					END-OF-LIFE Stage			
Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	De-construction/ Demolition	Transport to waste processing or disposal	Waste processing	Disposal of waste
A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**C1**	**C2**	**C3**	**C4**
X	**X**	**X**	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

Figure 1: Life-cycle stages and modules

Note: MND = module not declared; X = module included.

Cut-off

Items excluded from system boundary include: production, manufacture, and construction of manufacturing capital goods and infrastructure; production and manufacture of production equipment, delivery vehicles, and laboratory equipment; personnel-related activities (travel, furniture, and office supplies); and energy and water use related to company management and sales activities that may be located either within the factory site or at another location.

Allocation Procedure

Allocation follows the requirements and guidance of ISO 14044:2006, Clause 4.3.4.

The product category rules for this EPD recognize fly ash, silica fume and slag as waste products recovered materials and thus the environmental impacts allocated to these materials are limited to the treatment and transportation required to use as a concrete material input.

For mobile mixers 30% of all mixing truck(fleet) energy (fuel) has been allocated to module A3 and 70% is allocated to truck transit (and thus not included).

Life Cycle Inventory (LCI)

This EPD was calculated using both manufacturer specific cement, and industry average cement data. The manufacturer specific cement data represents 73% of the total cement used in each mix included in this EPD.

Primary Source of LCI Data

Portland area mobile mixer's primary data consist of both measured and estimated data gathered from mobile mix concrete companies. Mobile mix concrete's Data is derived from a plant-level questionnaire. Reported data is average data for the twelve-month period 1/1/2019 – 12/31/2019.

- Admixture (Air entrainer): EFCA EPD, 2015
- Admixture (Plasticizing): EFCA EPD, 2015
- Aggregate (crushed): US-EI (2020): "Gravel, crushed, at mine/US", 2001
- Aggregate (natural): US-EI (2020): "Gravel, round, at mine/US", 2001
- Cleaning Chemicals: Ecoinvent 3.4: 50% Citric acid and 50% Phosphoric acid, industrial grade, without water, in 70% solution state, market for/GLO, 2017
- Diesel: USLCI (2015): "Diesel, combusted in industrial equipment/NREL/US", 2007
- Electricity (WECC): Ecoinvent 3.4: "Electricity, medium voltage, market for, cut-off", 2014
- Non-Hazardous Solid Waste: US-EI (2018): Disposal, municipal solid waste, 2003
- Oils, Lubricants and Greases: Ecoinvent 3.4: Lubricating oil, GLO, market for, cut-off, 2017
- Portland cement: Portland Concrete Association, Industry Average EPD, 2014
- Portland Cement: Supplier specific primary data, 2020
- Propane: USLCI (2015): "Liquefied petroleum gas, at refinery/NREL/US", 2008
- Rail transport: USLCI (2015): "Transport, train, diesel powered NREL/US", 2007
- Truck transport: USLCI (2015): "Transport, combination truck, long-haul, diesel powered/tkm/RNA", 2014

The main processes included in the system boundary are illustrated in Figure 2.

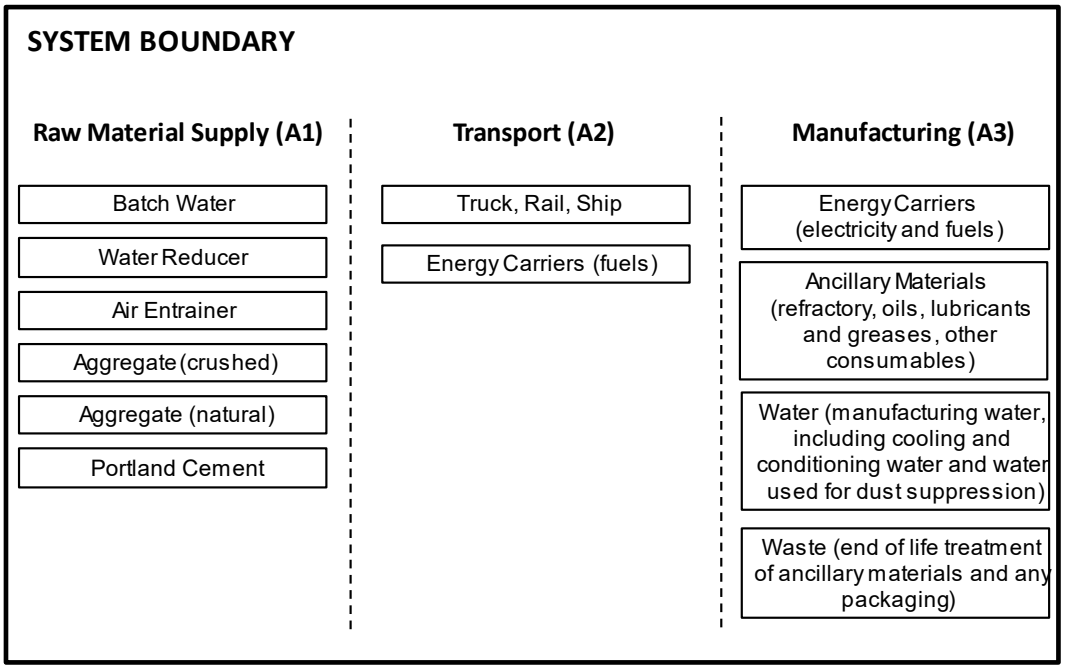

Figure 2: System Boundary for study

Electricity impacts are calculated based on the 2014 resource mix at the level of North American Electricity Reliability Council (NERC) WECC region. The 2014 grid mix contains: 29.2% Natural Gas, 22.6% Hydro, 14.3% Lignite, 13.9% Coal, 8.1% Nuclear, 6.6% Wind, 2.2 Geothermal, 1.7% BC import, 0.6% Wood Chips, 0.4% Biogas, 0.3% Solar.

References

- ISO 14020 (2000): Environmental labels and declarations – General principles
- ISO 14025 (2006): Environmental labels and declarations, Type III environmental declarations, Principles and procedures.
- ISO 14040(2020): ISO 14040; Environmental Management - Life Cycle Assessment - Principles and Framework.
- ISO 14044 (2006 Environmental management - Life cycle assessment - Requirements and guidelines. Amendment 2
- ISO 21930 (2017): ISO 21930; Sustainability in buildings and civil engineering works - Core rules for environmental product declarations of custruction products and services.
- NSF International (2019): PCR for Concrete.

Declaration of Environmental Indicators Derived from LCA Per 1 m³ of concrete

Impact Assessment	Unit	3000 psi mix	3500 psi mix	4000 psi mix	5000 psi mix
Global warming potential (GWP)	kg CO2 eq	332	354	381	434
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 eq	5.43E-06	5.76E-06	6.18E-06	7.02E-06
Eutrophication potential (EP)	kg N eq	0.24	0.25	0.27	0.30
Acidification potential of soil and water sources (AP)	kg SO2 eq	1.45	1.53	1.61	1.79
Formation potential of tropospheric ozone (POCP)	kg O3 eq	35.4	37.1	39.1	43.5
Resource Use					
Abiotic depletion potential for non-fossil mineral resources (ADPelements)*	kg Sb eq	5.02E-05	5.43E-05	5.89E-05	6.82E-05
Abiotic depletion potential for fossil resources (ADPfossil)	MJ	1,990	2,088	2,204	2,456
Renewable primary energy resources as energy (fuel), (RPRE)*	MJ	92.4	97.7	105.4	120.5
Renewable primary resources as material, (RPRM)*	MJ	0	0	0	0
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ	2,528	2,671	2,833	3,175
Non-renewable primary resources as material (NRPRM)*	MJ	0.94	0.93	0.93	0.93
Consumption of fresh water	m3	3.28	3.27	3.29	3.35
Secondary Material, Fuel and Recovered Energy					
Secondary Materials, (SM)*	kg	0	0	0	0
Renewable secondary fuels, (RSF)*	MJ	0	0	0	0
Non-renewable secondary fuels (NRSF)*	MJ	0	0	0	0
Recovered energy, (RE)*	MJ	0	0	0	0
Waste & Output Flows					
Hazardous waste disposed*	kg	8.22E-03	8.86E-03	9.62E-03	1.11E-02
Non-hazardous waste disposed*	kg	1.13	1.20	1.27	1.41
High-level radioactive waste*	m3	3.09E-08	3.16E-08	3.26E-08	3.47E-08
Intermediate and low-level radioactive waste*	m3	3.31E-07	3.47E-07	3.68E-07	4.12E-07
Components for reuse*	kg	0	0	0	0
Materials for recycling*	kg	0.46	0.46	0.46	0.46
Materials for energy recovery*	kg	0.03	0.03	0.03	0.03
Recovered energy exported from the product system*	MJ	0	0	0	0
Additional Inventory Parameters for Transparency					
Emissions from calcination*	kg CO2 eq	132	142	154	179

* 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 these categories.

Declaration of Environmental Indicators Derived from LCA
Per 1 cyd of concrete

Impact Assessment	Unit	3000 psi mix	3500 psi mix	4000 psi mix	5000 psi mix
Global warming potential (GWP)	kg CO2 eq	254	271	291	332
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 eq	4.15E-06	4.40E-06	4.72E-06	5.37E-06
Eutrophication potential (EP)	kg N eq	0.18	0.19	0.20	0.23
Acidification potential of soil and water sources (AP)	kg SO2 eq	1.11	1.17	1.23	1.37
Formation potential of tropospheric ozone (POCP)	kg O3 eq	27.0	28.3	29.9	33.2
Resource Use					
Abiotic depletion potential for non-fossil mineral resources (ADPelements)*	kg Sb eq	3.83E-05	4.15E-05	4.51E-05	5.22E-05
Abiotic depletion potential for fossil resources (ADPfossil)	MJ	1,521	1,597	1,685	1,877
Renewable primary energy resources as energy (fuel), (RPRE)*	MJ	70.6	74.7	80.6	92.1
Renewable primary resources as material, (RPRM)*	MJ	0	0	0	0
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ	1,932	2,042	2,166	2,428
Non-renewable primary resources as material (NRPRM)*	MJ	0.72	0.71	0.71	0.71
Consumption of fresh water	m3	2.51	2.50	2.51	2.56
Secondary Material, Fuel and Recovered Energy					
Secondary Materials, (SM)*	kg	0	0	0	0
Renewable secondary fuels, (RSF)*	MJ	0	0	0	0
Non-renewable secondary fuels (NRSF)*	MJ	0	0	0	0
Recovered energy, (RE)*	MJ	0	0	0	0
Waste & Output Flows					
Hazardous waste disposed*	kg	6.29E-03	6.77E-03	7.35E-03	8.50E-03
Non-hazardous waste disposed*	kg	0.86	0.92	0.97	1.08
High-level radioactive waste*	m3	2.37E-08	2.42E-08	2.49E-08	2.65E-08
Intermediate and low-level radioactive waste*	m3	2.53E-07	2.65E-07	2.82E-07	3.15E-07
Components for reuse*	kg	0	0	0	0
Materials for recycling*	kg	0.35	0.35	0.35	0.35
Materials for energy recovery*	kg	0.02	0.02	0.02	0.02
Recovered energy exported from the product system*	MJ	0	0	0	0
Additional Inventory Parameters for Transparency					
Emissions from calcination*	kg CO2 eq	101	109	118	137

* 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 these categories.

EPDs are comparable only if they comply with ISO 21930 (2017), use the same, sub-category PCR where applicable, include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works. This EPD was calculated using both manufacturer specific cement, and industry average cement data. 73% of the total cement used in an average mix included in this EPD is the manufacturer specific cement data and 27% is using the industry average value.