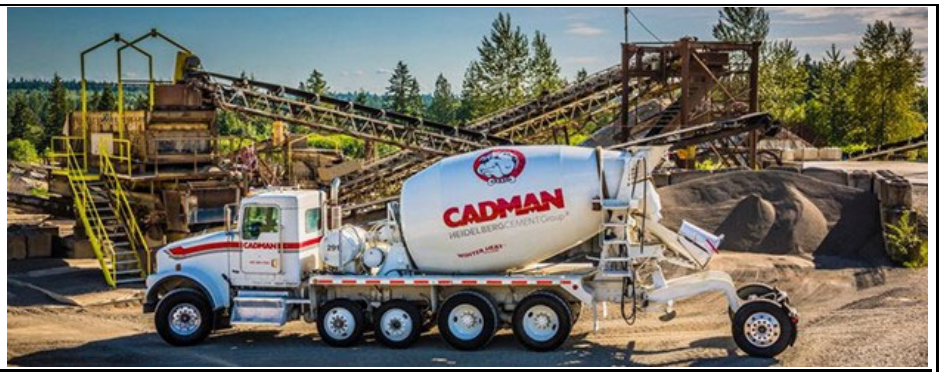
Environmental Product Declaration (EPD) for Concrete



Environmental Product Declaration Ready-Mix Concrete

(per ISO 14025 and ISO 21930)

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Product MC4SHO813

Cadman, Inc., *part of the Heidelberg Cement Group, has been serving the greater Puget Sound for more than 75 years. Cadman is committed to being the industry leader in providing outstanding value to our customers, a safe and stimulating work environment for our employees and also offering the latest in concrete technology. As a business that depends on natural resources, we are committed to operating in a socially and environmentally responsible manner.* ***Our Mission*** *is to supply our customers with sustainable and resilient ready mixed concrete - today, tomorrow and beyond.*

Authors of the Life Cycle Assessment:

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Certified Environmental Product Declaration
www.nsf.org

EPD Information			
Program Operator		NSF Certification, LLC	
Declaration Holder		Cadman, Inc.	
Product: P4SHO813	Date of Issue July 31, 2019	Period of Validity 5 Years	Declaration Number EPD10263
This EPD was independently verified by NSF Certification, LLC in accordance with ISO 14025 and ISO 21930: Internal **X** External		 Jenny Oorbeck joorbeck@nsf.org	
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR.		 Jack Geibig jgeibig@ecoform.com	
LCA Information			
Basis LCA		Life Cycle Assessment Manager for Concrete Environmental Product Declaration June 2017	
LCA Preparers		David Green/Anahi Grosse-Sommer BASF Corporation/BASF SE david.r.green@basf.com anahi.grosse-sommer@basf.com	
This life cycle assessment was critically reviewed in accordance with ISO 14044 by:		Jack Geibig - Ecoform jgeibig@ecoform.com	

North America PCR Information	
Program Operator	NSF International
Reference PCR	Product Category Rules (PCR) for ISO 14025:2006 Type III Environmental Product Declarations (EPDs) of Concrete, Version 2.0.
Date of Issue	February 22, 2019
PCR review was conducted by:	Thomas P. Gloria, Ph.D, Industrial Ecology Consultants; Bill Stough, Sustainable Research Group; Dr. Michael Overcash, Environmental Clarity.
EPD Software Tool	
LCA Software & Version Number	GaBi ts 8.5.079
LCI Database & Version Number	GaBi ts 8.5.0.79

ENVIRONMENTAL PRODUCT DECLARATION: DETAILED VERSION

Product Scope

This declaration and its LCA study are relevant to concrete and concrete products manufactured by Cadman, Inc. in Redmond, Washington. As the owner of the declaration Cadman, Inc. shall be liable for the underlying information and evidence; the program operator shall not be liable with respect to manufacturer information, life cycle assessment data and evidences.

Product Description

Products covered by this Environmental Product Declaration (EPD) are for specific concrete applications for commercial and/or residential construction developed and produced by Cadman, Inc. for markets in Redmond, Washington. The design compressive strength is 4,000 psi (27.6 mPa) at 28 days.

Concrete is batched and delivered in accordance with local standards. The producer provides product that meets or exceeds the standards based on standard operating procedures. Warranties and additional information are determined by the producer's terms and conditions.

During normal use, hardened concrete is stable and inert and does not pose a significant health or environmental hazard.

Fresh, plastic concrete must be managed in accordance with local regulations. Hardened concrete is an inert product and can be recycled subject to local regulations.

This EPD reports the impacts for the concrete components made of in-situ or ready-mixed concrete. The life cycle phases covered are A1 (Raw Material Supply: Upstream Processes), A2 (Transportation from Supplier to Gate of Producer) and A3 (Concrete Production – Core Process). This EPD is based on a cradle-to-gate system boundary deemed appropriate as concrete mixtures are supplied to a variety of products and the function of the final product is not specifically determined. Reference service life is not relevant due to the cradle-to-gate boundary conditions.

Life cycle stages that are not included in this EPD are A4 (Transportation to the Construction Site), A5 (Construction and Installation Process), B1-7 (Use Phase) and C1-4 (End of Life Stage).

Technical Data (* These characteristics are not relevant for ready-mix concrete)

Name	Value	Unit
Density	1,750 – 2,400	kg/m³
Thermal conductivity	*	W/(mK)
Water vapour diffusion resistance factor	*	-
Sound absorption coefficient	*	%
Compressive strength	17 - 110	N/mm²
Tensile strength	*	N/mm²
Flexural strength	*	N/mm²
Modulus of elasticity	*	N/mm²
Equilibrium moisture content	*	%

Product Components

The ready-mix concrete and its upstream materials covered by this Environmental Product Declaration conform to the appropriate ASTM standards as described in the NSF International PCR for Concrete, UNSPSC code 30111500, CSI Specification Section 03 30 00 or the requirements of European standard EN 206:2013, BS 8500-1:2015 and BS 8500-2:2015 based on the IBU PCR. Ready-mix concrete is generally batched at a plant, centrally mixed and then discharged into a truck mixer for delivery (central mixed) or dry-batched into the truck for mixing in the production yard, in transit or at the job site (truck mixed). Ready-mix concrete does not require packaging. The base material ranges for the defined ready-mix concrete are:

Material	*Amount*
Binders	10 – 20 %
Sands	50 – 70 %
Aggregates	20 - 40 %
Admixtures	< 1 %
Water	1 - 15 %

The product does not contain materials that are listed in the REACH “Candidate List of Substances of Very High Concern for Authorization”.

Production

Health and safety measures with potential impact to human health during manufacturing are to be consistently adhered to per regional regulatory requirements. Initiatives must be undertaken to minimize or eliminate potential impacts to the environment based on the use of best practices including engineered controls. Fresh, plastic concrete must be managed in accordance with local regulations. Hardened concrete is an inert product and can be recycled subject to local regulations. If disposed under the European waste catalogue, the waste code 17-01-01 for non-hazardous concrete and 17-01-06 for concrete containing hazardous substances is applicable. Any substances with hazardous and toxic properties that may be of concern to human health and/or the environment are provided in corresponding SDS documents based on regulatory requirements.

Declared Unit

The declared unit is 1 m^3 of Cadman, Inc. concrete produced for commercial applications with a specified compressive strength of 4,000 psi (27.6 mPa) at 28 days.

Cut-off Criteria

All material and energy flows known or suspected to release substances into the air, water or soil in quantities that contribute significantly to any of the indicators in ISO 21930 are included. In cases where there is insufficient input data for a unit process or data gaps, the cut-off criteria used is 1% of renewable primary resources (energy), 1% of non-renewable primary resource (energy) usage, 1% of the total mass input of that unit process and 1% of environmental impacts. The total of neglected input flows per module does not exceed 5%.

Life Cycle Assessment (LCA)

The LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

A summary of the life cycle stages ***included*** in the EPD is as follows:

I. Raw Material Supply (upstream processes): Extraction, handling and processing of the raw materials used in production of concrete: cement, supplementary cementitious materials, aggregate (coarse and fine), water, admixtures and other materials or chemicals used in concrete mixtures.

II. Transportation: Transportation of these materials from supplier to the 'gate' of the concrete producer.

III. Manufacturing (core processes): The core processes result from the energy used to store, batch, mix and distribute the concrete and operate the facility (concrete plant).

IV. Water use in mixing and distributing concrete.

The processes ***excluded*** from the EPD are as follows:

I. Production, manufacture and construction of buildings, capital goods and infrastructure with an expected lifespan of over 5 years.

II. Production and manufacture of concrete production equipment, concrete delivery vehicles, earth-moving equipment and laboratory equipment with an expected lifespan of over 5 years.

III. Personnel-related activities (travel, furniture, office supplies) as well as energy and water use related to company management and sales activities.

A summary of the limitations of this EPD include:

This EPD does not report all the environmental impacts due to manufacturing of the product, but rather reports the environmental impacts for those categories with established life cycle assessment-based methods to track and report. The product category rules for this EPD recognize fly ash, silica fume and slag as 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. Unreported environmental impacts include (but are not limited to) factors attributable to human health, land use change and habitat destruction.

This EPD reports the results of an LCA for 'cradle to gate' analysis and is intended for business-to-business communications. Thus, declarations themselves are not comparative assertions, defined as an environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function. An EPD does not make any statements that the product covered by the EPD is better or worse than any other product.

To assess the local impacts of product manufacturing, additional analysis is required.

Life cycle impact assessment results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Comparability:
EPD of concrete mixtures may not be comparable if they do not comply with this standard and data from this EPD. While an EPD can be used to compare concrete mixtures, the data cannot be used to compare between construction products or concrete mixtures used in different concrete products unless the data is integrated into a comprehensive LCA. For example, precast concrete, concrete masonry units and site cast concrete all have different manufacturing processes whose impacts are attributed to different LCA stages. This precludes direct comparison between mixtures used in these different products unless all life cycle phases are included, and a functional unit is used.

Allocation:
During the production of ready-mix concrete, co-products are not introduced into the mixture designs. Source-specific allocations are assigned to supplementary cementitious materials as these are considered secondary materials rather than co-products. For these secondary materials, all processing and transportation required to transform these materials to SCMs are included.

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycleing potential
A1	A2	A3	A4	A%	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

LCA: Interpretation and Results

The following tables provide the results of the LCA and the environmental parameters from the LCA for one (1) cubic meter of ready-mix concrete. The environmental impacts are based on the TRACI v2.1 characterization factors and NSF International PCR for Concrete.

Note: 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.

- Renewable primary energy resources as energy (fuel) (PERE)
- Renewable primary resources as material (PERM)
- Non-renewable primary resources as energy (fuel) (PENRE)
- Non-renewable primary resources as material (PENRM)
- Secondary Materials (SM)
- Renewable secondary fuels (RSF)
- Non-renewable secondary fuels (NRSF)
- Recovered energy (RE)
- Abiotic depletion potential for non-fossil mineral resources (ADPelements)
- 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.

Additional note: When upstream data specified in the PCR and/or used in calculating the EPD do not have data for select impact categories or inventory items, they are reported as an 'x' and not zero. Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete. Use caution when interpreting data in these categories.

Indicators describing environmental impacts:1 m3 Ready Mix Concrete - TRACI v 2.1	A1	A2	A3
Core mandatory impact indicators			
Global warming potential (GWP 100) [kg CO2 eq.]	3.05E+02	7.87E+00	5.39E+00
Ozone depletion potential (ODP) [kg CFC 11 eq.]	2.67E-08	2.96E-10	-2.86E-13
Acidification potential (AP) [kg SO2 eq]	5.57E-01	8.34E-02	1.52E-02
Eutrophication potential (EP) [kg N eq.]	3.04E-02	4.57E-03	6.52E-04
Photochemical smog creation potential (POCP) [kg O3 eq]	1.23E+01	2.40E+00	1.32E-01
Additional optional impact indicators			
Abiotic depletion potential for non fossil resources (ADPelements) [kg Sb eq]	4.97E-04	3.25E-09	1.46E-06

Indicators describing use of primary resources:1 m3 Ready Mix Concrete	A1	A2	A3
Renewable primary energy as energy carrier (PERE) [MJ]	2.21E+02	0.00E+00	1.16E+01
Primary energy resources used as raw materials (PERM) [MJ]	0.00E+00	0.00E+00	0.00E+00
Total use of renewable primary energy resources (PERT) [MJ]	2.21E+02	0.00E+00	1.16E+01
Non-renewable primary energy as energy carrier (PENRE) [MJ]	1.36E+03	9.99E+01	1.00E+02
Non-renewable primary energy resources used as raw materials (PENRM) [MJ]	0.00E+00	0.00E+00	0.00E+00
Total use of non-renewable primary energy resources (PENRT) [MJ]	1.36E+03	9.99E+01	1.00E+02

Indicators describing use of secondary resources:1 m3 Ready Mix Concrete	A1	A2	A3
Use of renewable secondary fuels (RSF) [MJ]	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary fuels (NRSF) [MJ]	0.00E+00	0.00E+00	0.00E+00
Components for reuse	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	0.00E+00	0.00E+00	0.00E+00
Recovered energy exported from the product system (RE) [MJ]	x	x	x

ADPfossil, consumption of fresh water	A1	A2	A3
Abiotic depletion potential for fossil resources (ADPfossil) [MJ]	1.17E+03	9.99E+01	8.16E+01
Use of net fresh water (FW) [m3]	5.04E-01	0.00E+00	2.97E-02
Concrete batching water (BW) [m3]	x	x	6.40E-02
Concrete washing water (WW) [m3]	x	x	7.29E-03

Indicators describing waste	A1	A2	A3
Hazardous waste disposed (HWD) [kg]	3.88E-06	0.00E+00	4.34E-08
Non-hazardous waste disposed (NHWD) [kg]	6.18E+01	0.00E+00	2.66E-02
Radioactive waste disposed (RWD) [kg]	7.71E-02	0.00E+00	7.28E-03
High level radioactive waste, conditioned, to final respository (HRWD) [kg]	x	x	x
Medium/low level radioactive waste, conditioned, to final repository (MRWD) [kg]	x	x	x

For the specific system boundaries identified for this EPD, the raw material supply (phase A1) is the primary driver for all environmental impact categories with this phase accounting for over 80% of the total results for GWP, ODP, AP, EP and POCP.

This is generally the result of the cement content in the concrete mixture as cement production requires high levels of energy for the calcining process while at the same time emitting CO_2 as part of the reaction from converting limestone ($CaCO_3$) to lime (CaO). Transportation may have a larger percentage of the total impact when raw materials are transported from long distances such as trans-oceanic locations.

Data Quality and Variability

The requirements for data quality and background data correspond with the requirements of the NSF International PCR for Concrete. The calculated data in this report is based on actual ready-mix concrete compositions. Manufacturer specific data is based on average data from the past 12 months.

The time over which inputs to and outputs from the system are accounted for is 100 year from the year for which the data is deemed representative.

The technology coverage reflects the physical reality for the declared ready-mix concrete product.

Used datasets are complete according to the system boundary within the limits set by the criteria for the exclusion of inputs and outputs.

To calculate the life cycle of the declared ready-mix concrete products, the software solution GaBi ts 8.5.0.79 from thinkstep AG was used. Background datasets were extracted from the GaBi database. The last revision of the GaBi data is less than 3 years ago according to thinkstep AG. Altogether, the data quality is considered high.

This EPD was created using the default data noted in appendix A of the NSF International PCR for concrete.

The following table summarizes the overall quality assessments for the main inputs for ready-mix concrete.

Inputs	Data Quality					
	Technology	*Time*	*Geography*	*Completeness*	*Reliability*	*Source*
Binders						
Cement (CEM I)	good	2018	Europe	good	good	Gabi 8.5
Portland cement	good	2016	US	good	good	Gabi 8.5/PCA
Fly ash	good	2018	Regional	good	good	Gabi 8.5
Blast furnace slag	good	2018	Germany	fair	good	Gabi 8.5/ASTM
Granite	good	2016	US	good	good	Gabi 8.5
Limestone	good	2017	Europe	good	good	Gabi 8.5
Glass	good	2016	Europe	good	good	Gabi 8.5
Natural pozzolan	good	2016	Global	good	good	Gabi 8.5
Lime	good	2016	US	good	good	Gabi 8.5
Kaolin	good	2016	Germany	good	good	Gabi 8.5
Silica fume	good	2017	US	fair	good	Gabi 8.5
Titanium dioxide	good	2016	US	good	good	Gabi 8.5
Iron oxide	good	2018	Germany	good	good	Gabi 8.5
Rice husk ash	fair	2017	US	fair	good	Gabi 8.5
Sands						
Natural sand	good	2016	Europe	good	good	Gabi 8.5/Ecoinvent
Natural sand, washed	good	2016	Europe	good	good	Gabi 8.5
Manufactured sand	good	2016	China	good	good	Gabi 8.5
Limestone powder	good	2017	Europe	good	good	Gabi 8.5
River dredge sand	fair	2016	Global	fair	good	Gabi 8.5
Aggregates						
Natural aggregate	good	2016	China	good	good	Gabi 8.5/Ecoinvent
Recycled aggregate	good	2016	US	good	good	Gabi 8.5
Recycled glass	fair	2016	Europe	fair	good	Gabi 8.5
Lightweight aggregate/expanded clay	good	2016	Europe	good	good	Gabi 8.5/Ecoinvent
Recycled concrete	good	2016	US	good	good	Gabi 8.5
Recycled tires	fair	2018	US	fair	good	Gabi 8.5
Limestone	good	2017	Europe	good	good	Gabi 8.5
Admixtures						
MasterPozzolith (WR)	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterPozzolith (MWR)	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterPolyheed	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterPolyheed (non-chloride)	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterRheobuild	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterGlenium	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterSet AC (non-chloride)	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterSet AC	good	2018	US/Europe	good	good	GaBi 8.5/BASF
Master X-Seed	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterSet (Retarder)	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterSet DELVO	good	2018	US/Europe	good	good	GaBi 8.5/BASF

MasterLife 300D	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterMatrix VMA	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterLife SRA	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterAir	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterSure Z 60	good	2018	US/Europe	good	good	GaBi 8.5/BASF
Mastercolor	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterKure ER	good	2018	US/Europe	good	good	GaBi 8.5/BASF
MasterLife CI	good	2018	US/Europe	good	good	GaBi 8.5/BASF
Water						
Water	good	2018	US/Germany	good	good	Gabi 8.5/Ecoinvent
Desalinated water	fair	2018	Middle East	fair	good	Gabi 8.5
Reinforcement						
Steel sections	good	2016	Global	good	good	Gabi 8.5
Reinforced steel	good	2016	Europe	good	good	Gabi 8.5
Polypropylene	good	2016	Europe	good	good	Gabi 8.5
MasterFiber MAC 2200 CB	good	2018	US	good	good	Gabi 8.5
Recycled PET	fair	2016	Europe	fair	good	Gabi 8.5
Recycled PP	fair	2016	Europe	fair	good	Gabi 8.5
Energy						
US Electricity grid mix	good	2016	US	good	good	Gabi 8.5/US LCI
EU-27 Electricity grid mix	good	2016	Europe	good	good	Gabi 8.5
US Natural gas	good	2016	US	good	good	Gabi 8.5/US LCI
EU-27 Natural gas	good	2016	Europe	good	good	Gabi 8.5
Packaging						
Pallet	good	2016	Europe	good	good	Gabi 8.5
Steel	good	2016	Global	fair	good	Gabi 8.5
Plastic	good	2016	Europe	fair	good	Gabi 8.5
Transport						
Truck	good	2016	Global/regional	good	good	Gabi 8.5/US LCI
Train	good	2018	Global/regional	good	good	Gabi 8.5/US LCI
Ship - river	good	2016	Global/regional	good	good	Gabi 8.5/US LCI
Ship - oceanic	good	2016	Global/regional	good	good	Gabi 8.5/US LCI

Ratings: good, fair, poor

References

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Product Category Rule for Environmental Product Declarations, PCR for Concrete version 2.0 February 22, 2019.

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REACH Directive (EG) No. 1907/2006 of the European Parliament and of the Council dated 18 December 2006 on the registration, evaluation, approval and restriction of chemical substances (REACH), for establishing a European Agency for chemical substances, for amending Directive 1999/45/EC and for annulment of Directive (EEC) No. 793/93 of the Council, Directive (EC) No. 1488/94 of the Commission, Guideline 76/769/EEC of the Council and Guidelines 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC of the Commission.

UNSPSC Code 30111500 Concrete and Mortars