

Environmental Product Declaration

A cradle-to-gate EPD according to ISO 14025 and ISO 21930



ASTM INTERNATIONAL



Precast/Prestressed Concrete Products
Manufactured by RAK Precast in Dubai, UAE



About RAK Precast

RAK PRECAST is one of the biggest factories in UAE with production capacity that can reach up to 1000 m³/day. We have two precast factories located in UAE and one factory in Iraq. Our factory established in Dubai Industrial City includes the latest automated precast systems.



We have a proven track record, for precast, pre-engineered buildings and associated civil engineering works which have significantly reduced construction cost & time for many of our clients. Within a short period, our group of companies are held in esteem throughout the construction industry of the area due to its conscious planning, maintaining honorable relationships with customers, and high-level jobsite performance.



ASTM INTERNATIONAL CERTIFIED EPD

This is a business-to-business Type III environmental product declaration (EPD) for precast concrete products as manufactured by RAK Precast. This declaration has been prepared in accordance with ISO 14025 and ISO 21930, and the ASTM product category rules (PCR) and EPD program operator rules.

The intent of this document is to further the development of environmentally compatible and more sustainable construction products by providing comprehensive environmental information related to potential impacts of precast concrete products available in the UAE in accordance with international standards.

Program Operator	
 ASTM INTERNATIONAL	ASTM International Environmental Product Declarations 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 www.astm.org
Owner of the EPD	
	RAK Precast PO BOX 54535 Jazirah Al Hamra New Ras Al Khaimah, United Arab Emirates
Precast Consultant	
	Grey Matters Consultancy P.O. Box: 283079 Dubai Investment Park Dubai - UAE www.greymatters.ws
EPD Information	
Product Names Structural precast, architectural precast, underground precast	Product Definition See Table 1
Declared Unit 1 tonne precast concrete product	Declaration Number EPD-106
Declaration Type A "cradle-to-gate" EPD - activity stages or information modules covered include production (modules A1 to A3). The declaration is intended for use in Business-to-Business (B-to-B) communication. This EPD of precast concrete products (UN CPC 3755) is applicable to those manufactured at the Emirates Precast Construction facility.	
Content of the Declaration The declaration follows Section 11, Content of the EPD, ASTM International, ASTM International, Product Category Rules for Preparing an Environmental Product Declaration For Precast Concrete.	

EPD Information						
Declaration Comparability Limitation Statement The following ISO statement indicates the EPD comparability limitations and intent to avoid any market distortions or misinterpretation of EPDs based on the ASTM's PCR, 2015: - EPDs from different programs (using different PCR) may not be comparable. - Declarations based on the ASTM PCR are not comparative assertions; that is, no claim of environmental superiority may be inferred or implied.						
Applicable Countries United Arab Emirates	Date of Issue May 14 2019	Period of Validity 5 years				
EPD Prepared by  Athena Sustainable Materials Institute		Matt Bowick, Athena Sustainable Materials Institute 280 Albert Street, Suite 404 Ottawa, Ontario, Canada, K1P 5G8 matt.bowick@athenasmi.org matt.bowick@athenasmi.org				
This EPD was independently verified by ASTM in accordance with ISO 14025: <table border="0"> <tr> <td>Internal</td> <td><u>External</u></td> </tr> <tr> <td></td> <td>X</td> </tr> </table>		Internal	<u>External</u>		X	 Timothy Brooke, ASTM International 100 Barr Harbor Dr. West Conshohocken, PA 19428 cert@astm.org
Internal	<u>External</u>					
	X					
EPD Project Report Information						
EPD Project Report A Cradle-to-Gate Life Cycle Assessment of Precast Concrete Products Manufactured by RAK Precast in the Emirate of Dubai, UAE The report is available upon request at cert@astm.org .						
EPD Project Prepared by  Athena Sustainable Materials Institute		Matt Bowick, Athena Sustainable Materials Institute 280 Albert Street, Suite 404 Ottawa, Ontario, Canada, K1P 5G8 matt.bowick@athenasmi.org				
This EPD and EPD project report were independently verified by in accordance with ISO 14025 and the reference PCR:		Thomas Gloria, Ph.D. (LCACP ID: 2008-03) Industrial Ecology Consultants Email: info@industrial-ecology.com				
PCR Information						
Reference PCR	ASTM International, Product Category Rules for Preparing an Environmental Product Declaration For Precast Concrete (based on ISO 21930:2007, an alternative to EN 15804 standard)					
Date of Issue	March 2015					
PCR review was conducted by:	Nicholas Santero, PE International (Chairperson) Christine Subasic, Consulting Architectural Engineer Juan Tejeda, ORCO Block Company Contact information available upon request at cert@astm.org .					

PRODUCT IDENTIFICATION

Precast concrete is a construction product produced by casting concrete in a reusable mold or "form" which is then cured in a controlled environment, transported to the construction site, and lifted into place. Precast concrete is used in building or civil engineering works and is primarily composed of cement, aggregates and reinforcement materials.

This EPD reports environmental information for the three precast concrete products types shown in Figure 1 below, produced by RAK Precast in Dubai, United Arab Emirates.



Structural precast products



Architectural precast



Underground precast

Figure 1: RAK Precast Concrete Products

Environmental information for products composed seven different concrete mix designs are reported in this EPD — see Table 1 for a summary of the products covered.

Table 1: Summary of Products Applicable to this EPD

Concrete Mix Design	Compressive Strength	Product Types (rebar design range, kg per m ³ product)
RAKP/CM/001	50 MPa	- Precast solid slabs (100-120) - Precast beams (100-150) - Precast stairs (80-100)
RAKP/CM/002	40 MPa	- Precast insulated wall panels (60-66.7) - Precast non-insulated wall panels (80-85)
RAKP/CM/003	40 MPa	- Precast insulated wall panels (60-66.7) - Precast non-insulated wall panels (80-85) - Precast footings (70-80)
RAKP/CM/004	15 MPa	Non-load-bearing light-weight partitions (0)
RAKP/CM/005	50 MPa	- Prestressed girders (200-250) - Prestressed beams (100-150)
RAKP/CM/006	50 MPa	- Precast columns (100-150) - Precast beams (100-150) - Precast footings (70-80) - Precast manholes (80-90)
RAKP/CM/007	50 MPa	Precast solid slabs (100-120)

DECLARED UNIT

The declared unit is 1 tonne of precast concrete product.

MATERIAL CONTENT

Table 2 through Table 14 below present the material content by input material for the various precast concrete products, as provided by Emirates Precast Construction.

To provide LCA results applicable to any future construction project, the rebar quantities of the six concrete mixes designs were varied between according to typical quantities, in increments of 5 kg/m³ or 10 kg/m³. It is intended that users of the EPD can reference the LCA results applicable to their design or interpolate between results.

Table 2: Material Content for Precast Insulated Panels – kg per m3 product

Material	RAKP/CM/002			RAKP/CM/003		
	Rebar = 60 kg/m ³	Rebar = 63.3 kg/m ³	Rebar = 66.7 kg/m ³	Rebar = 60 kg/m ³	Rebar = 63.3 kg/m ³	Rebar = 66.7 kg/m ³
Water	98.9	98.8	98.7	98.9	98.8	98.7
Portland Cement	176.2	176.1	175.9	162.5	162.3	162.2
Slag Cement (GGBFS)	98.9	98.8	98.7	98.9	98.8	98.7
Silica Fume	0.0	0.0	0.0	13.8	13.7	13.7
Crushed Coarse Aggregate, 20mm	452.1	451.6	451.2	452.1	451.6	451.2
Crushed Coarse Aggregate, 10mm	216.2	216.0	215.8	216.2	216.0	215.8
Crushed Fine Aggregate, 0-5mm	406.2	405.8	405.4	406.2	405.8	405.4
Natural Fine Aggregate, dune sand	157.2	157.1	156.9	157.2	157.1	156.9
Admixture - plasticizer	3.9	3.9	3.9	3.9	3.9	3.9
Rebar	60.0	63.3	66.7	60.0	63.3	66.7
EPS Insulation	10.2	10.2	10.2	10.2	10.2	10.2
Total	1,680	1,682	1,684	1,680	1,682	1,684

Table 3: Material Content for Precast Non-insulated Panels – kg per m3 product

Material	RAKP/CM/002		RAKP/CM/003	
	Rebar = 80 kg/m ³	Rebar = 85 kg/m ³	Rebar = 80 kg/m ³	Rebar = 85 kg/m ³
Water	149.3	149.2	149.5	149.4
Portland Cement	265.9	265.7	245.5	245.3
Slag Cement (GGBFS)	149.3	149.2	149.5	149.4
Silica Fume	0.0	0.0	20.8	20.8
Crushed Coarse Aggregate, 20mm	682.1	681.6	683.0	682.5
Crushed Coarse Aggregate, 10mm	326.2	326.0	326.6	326.4
Crushed Fine Aggregate, 0-5mm	612.9	612.5	613.7	613.3
Natural Fine Aggregate, dune sand	237.2	237.1	237.6	237.4
Admixture - plasticizer	5.9	5.9	5.9	5.9
Rebar	80	85	80	85
Total	2,509	2,512	2,512	2,515

Table 4: Material Content for Precast Solid Slabs – kg per m³ product

Material	RAKP/CM/001				
	Rebar = 100 kg/m ³	Rebar = 105 kg/m ³	Rebar = 110 kg/m ³	Rebar = 115 kg/m ³	Rebar = 120 kg/m ³
Water	164.9	164.8	164.7	164.6	164.4
Portland Cement	153.0	152.9	152.8	152.7	152.6
Slag Cement (GGBFS)	278.4	278.2	278.0	277.9	277.7
Silica Fume	32.6	32.6	32.5	32.5	32.5
Crushed Coarse Aggregate, 20mm	671.3	670.9	670.5	670.0	669.6
Crushed Coarse Aggregate, 10mm	325.8	325.6	325.4	325.2	325.0
Crushed Fine Aggregate, 0-5mm	602.2	601.8	601.5	601.1	600.7
Natural Fine Aggregate, dune sand	236.9	236.8	236.6	236.5	236.3
Admixture - plasticizer	6.9	6.9	6.9	6.9	6.9
Rebar	100	105	110	115	120
Total	2,572	2,576	2,579	2,582	2,586

Table 5: Material Content for Precast Solid Slabs – kg per m³ product (cont.)

Material	RAKP/CM/007				
	Rebar = 100 kg/m ³	Rebar = 105 kg/m ³	Rebar = 110 kg/m ³	Rebar = 115 kg/m ³	Rebar = 120 kg/m ³
Water	158.0	157.9	157.8	157.7	157.6
Portland Cement	264.6	264.4	264.2	264.1	263.9
Slag Cement (GGBFS)	166.8	166.7	166.6	166.5	166.4
Silica Fume	32.6	32.6	32.5	32.5	32.5
Crushed Coarse Aggregate, 20mm	656.5	656.1	655.7	655.3	654.8
Crushed Coarse Aggregate, 10mm	315.9	315.7	315.5	315.3	315.1
Crushed Fine Aggregate, 0-5mm	592.4	592.0	591.6	591.2	590.8
Natural Fine Aggregate, dune sand	232.0	231.9	231.7	231.6	231.4
Admixture - plasticizer	6.9	6.9	6.9	6.9	6.9
Rebar	100	105	110	115	120
Total	2,526	2,529	2,533	2,536	2,539

Table 6: Material Content for Precast Beams – kg per m³ product

Material	RAKP/CM/001					
	Rebar = 100 kg/m ³	Rebar = 110 kg/m ³	Rebar = 120 kg/m ³	Rebar = 130 kg/m ³	Rebar = 140 kg/m ³	Rebar = 150 kg/m ³
Water	164.9	164.7	164.4	164.2	164.0	163.8
Portland Cement	153.0	152.8	152.6	152.4	152.2	152.0
Slag Cement (GGBFS)	278.4	278.0	277.7	277.3	277.0	276.6
Silica Fume	32.6	32.5	32.5	32.5	32.4	32.4
Crushed Coarse Aggregate, 20mm	671.3	670.5	669.6	668.7	667.9	667.0
Crushed Coarse Aggregate, 10mm	325.8	325.4	325.0	324.5	324.1	323.7
Crushed Fine Aggregate, 0-5mm	602.2	601.5	600.7	599.9	599.1	598.3
Natural Fine Aggregate, dune sand	236.9	236.6	236.3	236.0	235.7	235.4
Admixture - plasticizer	6.9	6.9	6.9	6.9	6.9	6.9
Rebar	100	110	120	130	140	150
Total	2,572	2,579	2,586	2,593	2,599	2,606

Table 7: Material Content for Precast Beams – kg per m³ product (cont.)

Material	RAKP/CM/006					
	Rebar = 100 kg/m ³	Rebar = 110 kg/m ³	Rebar = 120 kg/m ³	Rebar = 130 kg/m ³	Rebar = 140 kg/m ³	Rebar = 150 kg/m ³
Water	156.0	155.8	155.6	155.4	155.2	155.0
Portland Cement	199.4	199.2	198.9	198.7	198.4	198.1
Slag Cement (GGBFS)	232.0	231.7	231.4	231.1	230.8	230.5
Silica Fume	32.6	32.5	32.5	32.5	32.4	32.4
Crushed Coarse Aggregate, 20mm	582.5	581.7	581.0	580.2	579.5	578.7
Crushed Coarse Aggregate, 10mm	414.6	414.1	413.6	413.0	412.5	412.0
Crushed Fine Aggregate, 0-5mm	552.9	552.2	551.4	550.7	550.0	549.3
Natural Fine Aggregate, dune sand	246.8	246.5	246.2	245.9	245.5	245.2
Admixture - superplasticizer	5.9	5.9	5.9	5.9	5.9	5.9
Rebar	100	110	120	130	140	150
Total	2,523	2,530	2,536	2,543	2,550	2,557

Table 8: Material Content for Prestressed Beams – kg per m³ product

Material	RAKP/CM/005					
	Rebar = 100 kg/m ³	Rebar = 110 kg/m ³	Rebar = 120 kg/m ³	Rebar = 130 kg/m ³	Rebar = 140 kg/m ³	Rebar = 150 kg/m ³
Water	150.1	149.9	149.7	149.5	149.3	149.1
Portland Cement	120.4	120.3	120.1	120.0	119.8	119.7
Slag Cement (GGBFS)	289.3	288.9	288.5	288.1	287.8	287.4
Silica Fume	35.5	35.5	35.4	35.4	35.4	35.3
Crushed Coarse Aggregate, 20mm	588.4	587.6	586.9	586.1	585.4	584.6
Crushed Coarse Aggregate, 10mm	422.5	422.0	421.5	420.9	420.4	419.8
Crushed Fine Aggregate, 0-5mm	554.8	554.1	553.4	552.7	552.0	551.3
Natural Fine Aggregate, dune sand	246.8	246.5	246.2	245.9	245.5	245.2
Admixture - superplasticizer	5.9	5.9	5.9	5.9	5.9	5.9
Rebar	100	110	120	130	140	150
Total	2,514	2,521	2,528	2,535	2,541	2,548

Table 9: Material Content for Prestressed Girders – kg per m³ product

Material	RAKP/CM/005					
	Rebar = 200 kg/m ³	Rebar = 210 kg/m ³	Rebar = 220 kg/m ³	Rebar = 230 kg/m ³	Rebar = 240 kg/m ³	Rebar = 250 kg/m ³
Water	148.1	147.9	147.7	147.5	147.4	147.2
Portland Cement	118.9	118.7	118.6	118.4	118.3	118.1
Slag Cement (GGBFS)	285.5	285.2	284.8	284.4	284.0	283.7
Silica Fume	35.1	35.0	35.0	34.9	34.9	34.9
Crushed Coarse Aggregate, 20mm	580.8	580.1	579.3	578.5	577.8	577.0
Crushed Coarse Aggregate, 10mm	417.1	416.6	416.0	415.5	414.9	414.4
Crushed Fine Aggregate, 0-5mm	547.7	547.0	546.2	545.5	544.8	544.1
Natural Fine Aggregate, dune sand	243.6	243.3	243.0	242.7	242.4	242.0
Admixture - superplasticizer	5.8	5.8	5.8	5.8	5.8	5.8
Rebar	200	210	220	230	240	250
Total	2,583	2,590	2,596	2,603	2,610	2,617

Table 10: Material Content for Precast Columns – kg per m³ product

Material	RAKP/CM/006					
	Rebar = 100 kg/m ³	Rebar = 110 kg/m ³	Rebar = 120 kg/m ³	Rebar = 130 kg/m ³	Rebar = 140 kg/m ³	Rebar = 150 kg/m ³
Water	156.0	155.8	155.6	155.4	155.2	155.0
Portland Cement	199.4	199.2	198.9	198.7	198.4	198.1
Slag Cement (GGBFS)	232.0	231.7	231.4	231.1	230.8	230.5
Silica Fume	32.6	32.5	32.5	32.5	32.4	32.4
Crushed Coarse Aggregate, 20mm	582.5	581.7	581.0	580.2	579.5	578.7
Crushed Coarse Aggregate, 10mm	414.6	414.1	413.6	413.0	412.5	412.0
Crushed Fine Aggregate, 0-5mm	552.9	552.2	551.4	550.7	550.0	549.3
Natural Fine Aggregate, dune sand	246.8	246.5	246.2	245.9	245.5	245.2
Admixture - superplasticizer	5.9	5.9	5.9	5.9	5.9	5.9
Rebar	100	110	120	130	140	150
Total	2,523	2,530	2,536	2,543	2,550	2,557

Table 11: Material Content for Precast Footings – kg per m³ product

Material	RAKP/CM/003			RAKP/CM/006		
	Rebar = 70 kg/m ³	Rebar = 75 kg/m ³	Rebar = 80 kg/m ³	Rebar = 70 kg/m ³	Rebar = 75 kg/m ³	Rebar = 80 kg/m ³
Water	149.7	149.6	149.5	156.6	156.5	156.4
Portland Cement	245.8	245.6	245.5	200.2	200.1	199.9
Slag Cement (GGBFS)	149.7	149.6	149.5	232.9	232.8	232.6
Silica Fume	20.8	20.8	20.8	32.7	32.7	32.7
Crushed Coarse Aggregate, 20mm	683.8	683.4	683.0	584.7	584.4	584.0
Crushed Coarse Aggregate, 10mm	327.1	326.8	326.6	416.3	416.0	415.7
Crushed Fine Aggregate, 0-5mm	614.5	614.1	613.7	555.0	554.6	554.3
Natural Fine Aggregate, dune sand	237.9	237.7	237.6	247.8	247.6	247.5
Admixture - plasticizer	5.9	5.9	5.9	0.0	0.0	0.0
Admixture - superplasticizer	0.0	0.0	0.0	5.9	5.9	5.9
Rebar	70	75	80	70	75	80
Total	2,505	2,509	2,512	2,502	2,506	2,509

Table 12: Material Content for Precast Stairs – kg per m³ product

Material	RAKP/CM/001				
	Rebar = 80 kg/m ³	Rebar = 85 kg/m ³	Rebar = 90 kg/m ³	Rebar = 95 kg/m ³	Rebar = 100 kg/m ³
Water	165.3	165.2	165.1	165.0	164.9
Portland Cement	153.4	153.3	153.2	153.1	153.0
Slag Cement (GGBFS)	279.1	278.9	278.8	278.6	278.4
Silica Fume	32.7	32.6	32.6	32.6	32.6
Crushed Coarse Aggregate, 20mm	673.1	672.6	672.2	671.8	671.3
Crushed Coarse Aggregate, 10mm	326.6	326.4	326.2	326.0	325.8
Crushed Fine Aggregate, 0-5mm	603.8	603.4	603.0	602.6	602.2
Natural Fine Aggregate, dune sand	237.6	237.4	237.2	237.1	236.9
Admixture - plasticizer	6.9	6.9	6.9	6.9	6.9
Rebar	80	85	90	95	100
EPS Insulation	0.0	0.0	0.0	0.0	0.0
Total	2,558	2,562	2,565	2,569	2,572

Table 13: Material Content for Precast Manholes – kg per m³ product

Material	RAKP/CM/006		
	Rebar = 80 kg/m ³	Rebar = 85 kg/m ³	Rebar = 90 kg/m ³
Water	156.4	156.3	156.2
Portland Cement	199.9	199.8	199.7
Slag Cement (GGBFS)	232.6	232.5	232.3
Silica Fume	32.7	32.6	32.6
Crushed Coarse Aggregate, 20mm	584.0	583.6	583.2
Crushed Coarse Aggregate, 10mm	415.7	415.5	415.2
Crushed Fine Aggregate, 0-5mm	554.3	553.9	553.6
Natural Fine Aggregate, dune sand	247.5	247.3	247.1
Admixture - superplasticizer	5.9	5.9	5.9
Rebar	80	85	90
Total	2,509	2,512	2,516

Table 14: Material Content for Non-load-bearing Light-weight Partitions – kg per m³ product

Material	RAKP/CM/004	
	Rebar = 0 kg/m ³	
Water	140.0	
Portland Cement	400.0	
Crushed Fine Aggregate, 0-5mm	370.0	
Natural Fine Aggregate, dune sand	130.0	
Manufactured Lightweight Aggregate	410.0	
Rebar	0.0	
Total	1,450	

SYSTEM BOUNDARY

As per the ASTM PCR, the system boundary is the product stage, which includes the following modules:

- A1 Raw material supply;
- A2 Transport (to the manufacturer); and
- A3 Manufacturing.

Figure 2 shows the production stage system boundary for precast concrete products.

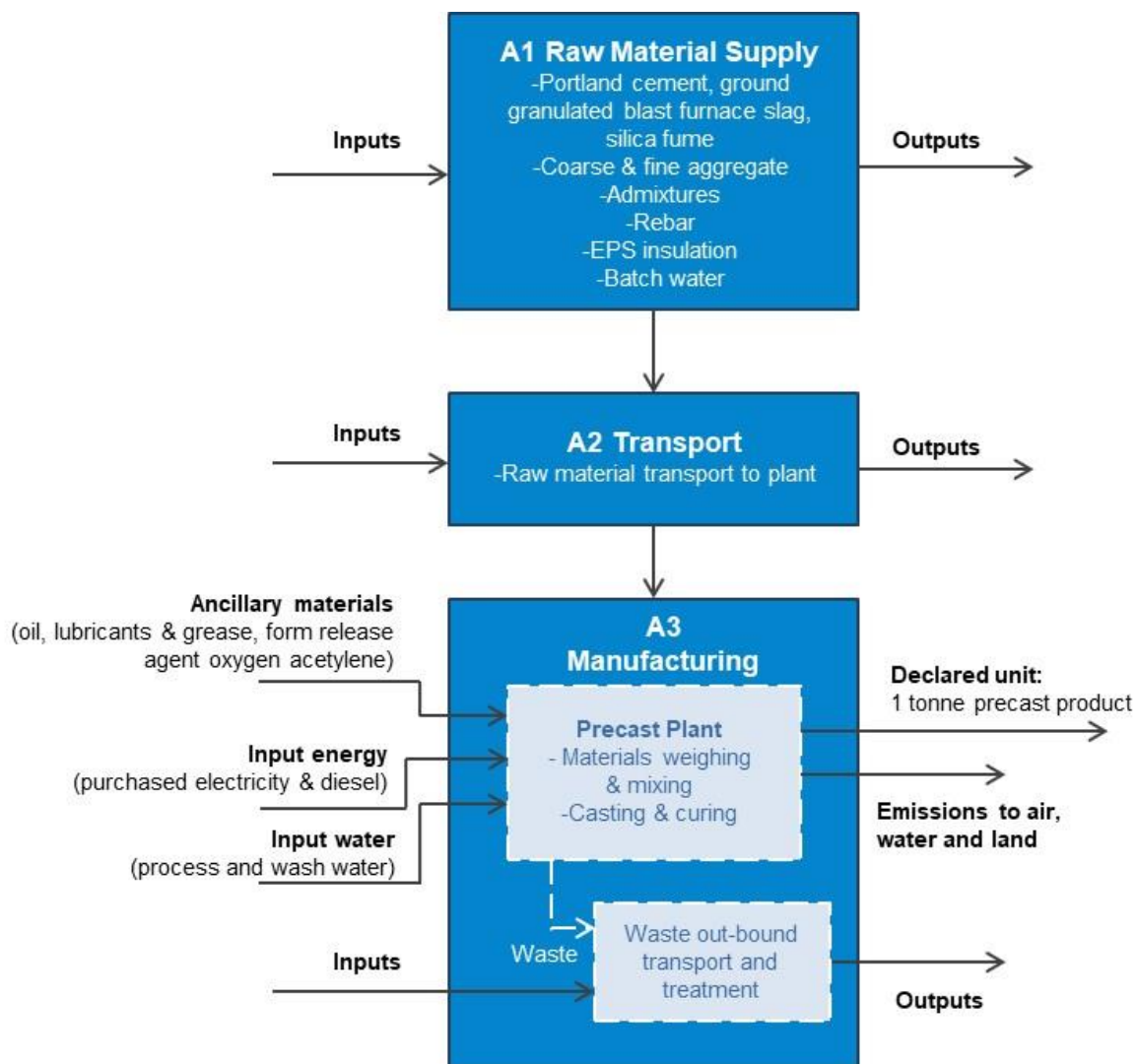


Figure 2: Product Stage (module A1 to A3) System Boundary

LIFE CYCLE ASSESSMENT

This section summarizes the results of the life cycle impact assessment (LCIA) based on the cradle-to-gate life cycle inventory inputs and outputs analysis. The results are calculated on the basis of 1 tonne precast concrete product. As per the ASTM PCR, Section 8, US EPA Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI, version 2.1) impact categories are used for the mandatory category indicators to be included in this EPD. These are relative expressions only and do not predict category impact end-points, the exceeding of thresholds, safety margins or risks. Total primary and sub-set energy consumption was compiled using a cumulative energy demand model. Material resource consumption and generated waste reflect cumulative life cycle inventory flow information.

Table 15: Results (A1-A3): Precast Insulated Panels, per tonne product

Environmental Indicator	Unit	RAKP/CM/002			RAKP/CM/003		
		Rebar = 60 kg/m ³	Rebar = 63.3 kg/m ³	Rebar = 66.7 kg/m ³	Rebar = 60 kg/m ³	Rebar = 63.3 kg/m ³	Rebar = 66.7 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	222	226	231	217	282	290
Acidification potential	kg SO ₂ eq.	0.97	0.99	1.01	0.97	1.29	1.33
Eutrophication potential	kg N eq.	0.172	0.173	0.174	0.165	0.178	0.180
Smog creation potential	kg O ₃ eq.	7.72	7.73	7.75	7.71	7.97	7.99
Ozone depletion potential	kg CFC-11 eq.	3.15E-05	3.15E-05	3.14E-05	3.12E-05	3.13E-05	3.13E-05
Nonrenewable energy resources	MJ (HHV)	3,005	3,069	3,133	2,974	3,879	3,987
Renewable energy resources	MJ (HHV)	79	81	83	78	108	112
Nonrenewable material resources	kg	742	744	746	733	765	769
Renewable material resources	kg	1.221	1.233	1.244	1.217	1.389	1.409
Net fresh water (inputs minus outputs)	L	1,155	1,162	1,168	1,115	1,210	1,221
Non-hazardous waste generated	kg	11.0	11.0	11.0	11.0	11.0	11.0
Hazardous waste generated	kg	1.95	2.05	2.16	1.95	3.39	3.57

Table 16: Results (A1-A3): Precast Non-insulated Panels, per tonne product

Environmental Indicator	Unit	RAKP/CM/002		RAKP/CM/003	
		Rebar = 80 kg/m ³	Rebar = 85 kg/m ³	Rebar = 80 kg/m ³	Rebar = 85 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	245	250	238	243
Acidification potential	kg SO ₂ eq.	1.07	1.09	1.06	1.09
Eutrophication potential	kg N eq.	0.211	0.212	0.201	0.202
Smog creation potential	kg O ₃ eq.	9.67	9.68	9.65	9.67
Ozone depletion potential	kg CFC-11 eq.	4.59E-05	4.59E-05	4.55E-05	4.55E-05
Nonrenewable energy resources	MJ (HHV)	2,951	3,014	2,903	2,966
Renewable energy resources	MJ (HHV)	81	83	81	83
Nonrenewable material resources	kg	1,086	1,088	1,073	1,074
Renewable material resources	kg	1.510	1.522	1.505	1.516
Net fresh water (inputs minus outputs)	L	1,074	1,080	1,014	1,020
Non-hazardous waste generated	kg	16.5	16.5	16.5	16.5
Hazardous waste generated	kg	1.78	1.89	1.78	1.88

Table 17: Results (A1-A3): Precast Solid Slabs, per tonne product

Environmental Indicator	Unit	RAKP/CM/001				
		Rebar = 100 kg/m ³	Rebar = 105 kg/m ³	Rebar = 110 kg/m ³	Rebar = 115 kg/m ³	Rebar = 120 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	225	229	234	238	243
Acidification potential	kg SO ₂ eq.	1.21	1.23	1.25	1.27	1.30
Eutrophication potential	kg N eq.	0.162	0.162	0.163	0.164	0.165
Smog creation potential	kg O ₃ eq.	9.65	9.67	9.68	9.69	9.70
Ozone depletion potential	kg CFC-11 eq.	4.30E-05	4.29E-05	4.29E-05	4.29E-05	4.29E-05
Nonrenewable energy resources	MJ (HHV)	2,977	3,038	3,099	3,159	3,220
Renewable energy resources	MJ (HHV)	90	92	94	96	98
Nonrenewable material resources	kg	1,049	1,051	1,052	1,054	1,055
Renewable material resources	kg	1.498	1.509	1.520	1.531	1.542
Net fresh water (inputs minus outputs)	L	755	761	767	773	779
Non-hazardous waste generated	kg	16.5	16.5	16.5	16.5	16.5
Hazardous waste generated	kg	2.15	2.25	2.35	2.45	2.54

Table 18: Results (A1-A3): Precast Solid Slabs, per tonne product (cont.)

Environmental Indicator	Unit	RAKP/CM/007				
		Rebar = 100 kg/m ³	Rebar = 105 kg/m ³	Rebar = 110 kg/m ³	Rebar = 115 kg/m ³	Rebar = 120 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	265	269	273	278	282
Acidification potential	kg SO ₂ eq.	1.20	1.23	1.25	1.27	1.29
Eutrophication potential	kg N eq.	0.216	0.217	0.218	0.218	0.219
Smog creation potential	kg O ₃ eq.	10.31	10.32	10.33	10.35	10.36
Ozone depletion potential	kg CFC-11 eq.	4.55E-05	4.54E-05	4.54E-05	4.54E-05	4.54E-05
Nonrenewable energy resources	MJ (HHV)	3,227	3,289	3,351	3,412	3,474
Renewable energy resources	MJ (HHV)	90	92	94	96	98
Nonrenewable material resources	kg	1,075	1,076	1,078	1,080	1,081
Renewable material resources	kg	1.554	1.565	1.576	1.587	1.598
Net fresh water (inputs minus outputs)	L	1,097	1,103	1,109	1,115	1,121
Non-hazardous waste generated	kg	16.5	16.5	16.5	16.5	16.5
Hazardous waste generated	kg	2.19	2.29	2.39	2.49	2.59

Table 19: Results (A1-A3): Precast Beams, per tonne product

Environmental Indicator	Unit	RAKP/CM/001					
		Rebar = 100 kg/m ³	Rebar = 110 kg/m ³	Rebar = 120 kg/m ³	Rebar = 130 kg/m ³	Rebar = 140 kg/m ³	Rebar = 150 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	225	234	243	251	260	268
Acidification potential	kg SO ₂ eq.	1.21	1.25	1.30	1.34	1.38	1.42
Eutrophication potential	kg N eq.	0.162	0.163	0.165	0.166	0.168	0.170
Smog creation potential	kg O ₃ eq.	9.65	9.68	9.70	9.73	9.75	9.77
Ozone depletion potential	kg CFC-11 eq.	4.30E-05	4.29E-05	4.29E-05	4.28E-05	4.28E-05	4.28E-05
Nonrenewable energy resources	MJ (HHV)	2,977	3,099	3,220	3,340	3,460	3,579
Renewable energy resources	MJ (HHV)	90	94	98	102	106	109
Nonrenewable material resources	kg	1,049	1,052	1,055	1,059	1,062	1,065
Renewable material resources	kg	1.498	1.520	1.542	1.563	1.585	1.606
Net fresh water (inputs minus outputs)	L	755	767	779	791	803	815
Non-hazardous waste generated	kg	16.5	16.5	16.5	16.5	16.4	16.4
Hazardous waste generated	kg	2.15	2.35	2.54	2.74	2.93	3.13

Table 20: Results (A1-A3): Precast Beams, per tonne product (cont.)

Environmental Indicator	Unit	RAKP/CM/006					
		Rebar = 100 kg/m ³	Rebar = 110 kg/m ³	Rebar = 120 kg/m ³	Rebar = 130 kg/m ³	Rebar = 140 kg/m ³	Rebar = 150 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	244	253	261	270	279	288
Acidification potential	kg SO ₂ eq.	1.22	1.26	1.31	1.35	1.39	1.44
Eutrophication potential	kg N eq.	0.186	0.187	0.189	0.191	0.192	0.194
Smog creation potential	kg O ₃ eq.	10.01	10.03	10.06	10.08	10.10	10.13
Ozone depletion potential	kg CFC-11 eq.	4.42E-05	4.41E-05	4.41E-05	4.40E-05	4.40E-05	4.40E-05
Nonrenewable energy resources	MJ (HHV)	3,105	3,229	3,352	3,475	3,596	3,717
Renewable energy resources	MJ (HHV)	91	95	99	103	107	111
Nonrenewable material resources	kg	1,063	1,066	1,069	1,073	1,076	1,079
Renewable material resources	kg	1.539	1.561	1.584	1.606	1.627	1.649
Net fresh water (inputs minus outputs)	L	904	916	928	940	952	964
Non-hazardous waste generated	kg	16.5	16.5	16.5	16.4	16.4	16.4
Hazardous waste generated	kg	2.19	2.39	2.59	2.79	2.99	3.19

Table 21: Results (A1-A3): Prestressed Beams, per tonne product

Environmental Indicator	Unit	RAKP/CM/005					
		Rebar = 100 kg/m ³	Rebar = 110 kg/m ³	Rebar = 120 kg/m ³	Rebar = 130 kg/m ³	Rebar = 140 kg/m ³	Rebar = 150 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	218	227	236	245	254	262
Acidification potential	kg SO ₂ eq.	1.22	1.26	1.31	1.35	1.39	1.44
Eutrophication potential	kg N eq.	0.148	0.150	0.152	0.153	0.155	0.157
Smog creation potential	kg O ₃ eq.	9.50	9.52	9.55	9.57	9.59	9.62
Ozone depletion potential	kg CFC-11 eq.	4.27E-05	4.27E-05	4.26E-05	4.26E-05	4.25E-05	4.25E-05
Nonrenewable energy resources	MJ (HHV)	2,955	3,079	3,203	3,326	3,448	3,570
Renewable energy resources	MJ (HHV)	91	95	99	103	107	111
Nonrenewable material resources	kg	1,047	1,051	1,054	1,057	1,061	1,064
Renewable material resources	kg	1.525	1.547	1.569	1.591	1.613	1.635
Net fresh water (inputs minus outputs)	L	673	685	698	710	723	735
Non-hazardous waste generated	kg	16.5	16.5	16.5	16.5	16.4	16.4
Hazardous waste generated	kg	2.20	2.40	2.60	2.80	3.00	3.20

Table 22: Results (A1-A3): Prestressed Girders, per tonne product

Environmental Indicator	Unit	RAKPI/CM/005					
		Rebar = 200 kg/m ³	Rebar = 210 kg/m ³	Rebar = 220 kg/m ³	Rebar = 230 kg/m ³	Rebar = 240 kg/m ³	Rebar = 250 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	306	314	323	337	339	348
Acidification potential	kg SO ₂ eq.	1.65	1.69	1.73	1.80	1.81	1.85
Eutrophication potential	kg N eq.	0.165	0.166	0.168	0.171	0.171	0.172
Smog creation potential	kg O ₃ eq.	9.73	9.76	9.78	9.82	9.82	9.85
Ozone depletion potential	kg CFC-11 eq.	4.23E-05	4.23E-05	4.22E-05	4.22E-05	4.21E-05	4.21E-05
Nonrenewable energy resources	MJ (HHV)	4,168	4,286	4,403	4,598	4,636	4,751
Renewable energy resources	MJ (HHV)	131	135	139	145	146	150
Nonrenewable material resources	kg	1,079	1,082	1,085	1,091	1,091	1,094
Renewable material resources	kg	1.743	1.764	1.785	1.821	1.826	1.847
Net fresh water (inputs minus outputs)	L	795	807	819	839	842	854
Non-hazardous waste generated	kg	16.3	16.3	16.3	16.3	16.2	16.2
Hazardous waste generated	kg	4.17	4.36	4.55	4.87	4.93	5.12

Table 23: Results (A1-A3): Precast Columns, per tonne product

Environmental Indicator	Unit	RAKPI/CM/006					
		Rebar = 100 kg/m ³	Rebar = 110 kg/m ³	Rebar = 120 kg/m ³	Rebar = 130 kg/m ³	Rebar = 140 kg/m ³	Rebar = 150 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	244	253	261	270	279	288
Acidification potential	kg SO ₂ eq.	1.22	1.26	1.31	1.35	1.39	1.44
Eutrophication potential	kg N eq.	0.186	0.187	0.189	0.191	0.192	0.194
Smog creation potential	kg O ₃ eq.	10.01	10.03	10.06	10.08	10.10	10.13
Ozone depletion potential	kg CFC-11 eq.	4.42E-05	4.41E-05	4.41E-05	4.40E-05	4.40E-05	4.40E-05
Nonrenewable energy resources	MJ (HHV)	3,105	3,229	3,352	3,475	3,596	3,717
Renewable energy resources	MJ (HHV)	91	95	99	103	107	111
Nonrenewable material resources	kg	1,063	1,066	1,069	1,073	1,076	1,079
Renewable material resources	kg	1.539	1.561	1.584	1.606	1.627	1.649
Net fresh water (inputs minus outputs)	L	904	916	928	940	952	964
Non-hazardous waste generated	kg	16.5	16.5	16.5	16.4	16.4	16.4
Hazardous waste generated	kg	2.19	2.39	2.59	2.79	2.99	3.19

Table 24: Results (A1-A3): Precast Footings, per tonne product

Environmental Indicator	Unit	RAKP/CM/003			RAKP/CM/006		
		Rebar = 70 kg/m ³	Rebar = 75 kg/m ³	Rebar = 80 kg/m ³	Rebar = 70 kg/m ³	Rebar = 75 kg/m ³	Rebar = 80 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	229	233	238	217	221	226
Acidification potential	kg SO ₂ eq.	1.02	1.04	1.06	1.09	1.11	1.13
Eutrophication potential	kg N eq.	0.199	0.200	0.201	0.181	0.182	0.182
Smog creation potential	kg O ₃ eq.	9.63	9.64	9.65	9.94	9.95	9.96
Ozone depletion potential	kg CFC-11 eq.	4.55E-05	4.55E-05	4.55E-05	4.43E-05	4.43E-05	4.42E-05
Nonrenewable energy resources	MJ (HHV)	2,778	2,841	2,903	2,730	2,793	2,856
Renewable energy resources	MJ (HHV)	77	79	81	78	80	82
Nonrenewable material resources	kg	1,069	1,071	1,073	1,053	1,055	1,056
Renewable material resources	kg	1.482	1.494	1.505	1.472	1.483	1.494
Net fresh water (inputs minus outputs)	L	1,002	1,008	1,014	867	873	879
Non-hazardous waste generated	kg	16.6	16.6	16.5	16.6	16.6	16.5
Hazardous waste generated	kg	1.58	1.68	1.78	1.58	1.68	1.79

Table 25: Results (A1-A3): Precast Stairs, per tonne product

Environmental Indicator	Unit	RAKP/CM/001				
		Rebar = 80 kg/m ³	Rebar = 85 kg/m ³	Rebar = 90 kg/m ³	Rebar = 95 kg/m ³	Rebar = 100 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	207	212	216	221	225
Acidification potential	kg SO ₂ eq.	1.12	1.15	1.17	1.19	1.21
Eutrophication potential	kg N eq.	0.158	0.159	0.160	0.161	0.162
Smog creation potential	kg O ₃ eq.	9.61	9.62	9.63	9.64	9.65
Ozone depletion potential	kg CFC-11 eq.	4.30E-05	4.30E-05	4.30E-05	4.30E-05	4.30E-05
Nonrenewable energy resources	MJ (HHV)	2,732	2,794	2,855	2,916	2,977
Renewable energy resources	MJ (HHV)	82	84	86	88	90
Nonrenewable material resources	kg	1,043	1,044	1,046	1,048	1,049
Renewable material resources	kg	1.454	1.465	1.476	1.487	1.498
Net fresh water (inputs minus outputs)	L	730	736	742	749	755
Non-hazardous waste generated	kg	16.6	16.5	16.5	16.5	16.5
Hazardous waste generated	kg	1.75	1.85	1.95	2.05	2.15

Table 26: Results (A1-A3): Precast Manholes, per tonne product

Environmental Indicator	Unit	RAKP/CM/006		
		Rebar = 80 kg/m ³	Rebar = 85 kg/m ³	Rebar = 90 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	226	230	235
Acidification potential	kg SO ₂ eq.	1.13	1.15	1.18
Eutrophication potential	kg N eq.	0.182	0.183	0.184
Smog creation potential	kg O ₃ eq.	9.96	9.97	9.98
Ozone depletion potential	kg CFC-11 eq.	4.42E-05	4.42E-05	4.42E-05
Nonrenewable energy resources	MJ (HHV)	2,856	2,918	2,981
Renewable energy resources	MJ (HHV)	82	85	87
Nonrenewable material resources	kg	1,056	1,058	1,060
Renewable material resources	kg	1.494	1.505	1.517
Net fresh water (inputs minus outputs)	L	879	885	892
Non-hazardous waste generated	kg	16.5	16.5	16.5
Hazardous waste generated	kg	1.79	1.89	1.99

Table 27: Results (A1-A3): Precast Non-load-bearing Light-weight Partitions, per tonne product

Environmental Indicator	Unit	RAKP/CM/004 Rebar = 0 kg/m ³
Global warming potential (GWP)	kg CO ₂ eq.	477
Acidification potential	kg SO ₂ eq.	1.959
Eutrophication potential	kg N eq.	0.732
Smog creation potential	kg O ₃ eq.	24.00
Ozone depletion potential	kg CFC-11 eq.	5.87E-05
Nonrenewable energy resources	MJ (HHV)	4,567
Renewable energy resources	MJ (HHV)	175
Nonrenewable material resources	kg	1,142
Renewable material resources	kg	5.750
Net fresh water (inputs minus outputs)	L	2,426
Non-hazardous waste generated	kg	16.5
Hazardous waste generated	kg	0.19