INDIA

EPD®

THE INTERNATIONAL EPD SYSTEM

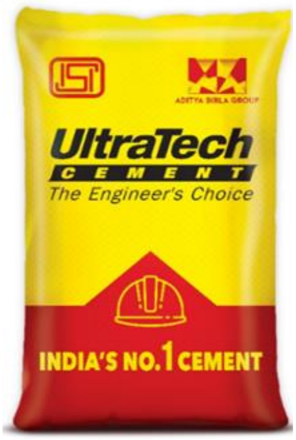
ADITYA BIRLA

UltraTech

Cement Product (OPC, PPC, PSC, PCC)

From UltraTech Cement Ltd.

In accordance with ISO 14025 & EN 15804:2012+A2:2019



Programme:	*The International EPD® System, www.environdec. com*
Programme operator:	*EPD International AB*
EPD registration number:	*S-P-05019*
Publication date:	*2022-08-02*
Valid until:	*2027-08-01*

ECO PLATFORM EPD VERIFIED

EPD® THE INTERNATIONAL EPD® SYSTEM

1. Introduction

UltraTech Cement Limited is the cement flagship company of the Aditya Birla Group. It is the largest manufacturer of grey cement and ready-mix concrete (RMC) and one of the largest manufacturers of white cement in India. It is the third largest cement producer in the world, excluding China. UltraTech is the only cement company globally (outside of China) to have 100+ MTPA of cement manufacturing capacity in a single country. The Company's business operations span UAE, Bahrain, Sri Lanka and India.

UltraTech has a consolidated capacity of 119.95 million Tonnes Per Annum (MTPA) of grey cement. It has 22 integrated manufacturing units, 27 grinding units, one Clinkerisation unit and 8 Bulk Packaging Terminals. UltraTech is a founding member of Global Cement and Concrete Association (GCCA). It is a signatory to the GCCA Climate Ambition 2050 and has committed to the Net Zero Concrete Roadmap announced by GCCA. Focusing on accelerating the decarbonisation of its operations they have also adopted new age tools like the Science Based Targets Initiative (SBTi) and Internal Carbon Price as well as set ambitious environmental targets through both EP100 and RE100.

UltraTech is also committed to drive sustainability across the value chain of its operations. To achieve this, they focus on carbon emissions, energy reduction, water management, waste management, biodiversity management, resource management, community relationship management, occupational health and safety, human rights management, employee well-being and product development.

Thinkstep Sustainability Solutions Pvt. Ltd, a Sphera Company (formerly thinkstep AG). has been entrusted to conduct Life Cycle Assessment for 4 cement products i.e., OPC, PPC, PSC and PCC as per the standards ISO 14040:2006 (and its amendment 14040:2006/Amd 1:2020), ISO 14044:2006 (and its amendments 14044:2006/Amd 1:2018 and 14044:2006/Amd 2:2020) along with EN15804-A2:2019 (Core rules for the product category of construction products) and c-PCR-001 Cement and Building Lime (EN 16908) for the preparation of Environmental Product Declaration (EPD).

The LCA model was created using the GaBi 10.5 Software system for life cycle engineering, developed by Sphera (formerly thinkstep AG).

2. General Information

2.1 EPD, PCR, LCA Information

Table 2-1 EPD Information

Programme	The International EPD System www.environdec.com	
Program operator	EPD International AB Box 210 60, SE-100 31 Stockholm, Sweden.	Indian Regional Hub www.environdecindia.com
Declaration holder	Mr. Vishal Bhavsar UltraTech Cement Pvt. Ltd, Ahura Centre, B Wing, 2nd Floor, Mahakali Caves Road, Andheri East, Mumbai, Maharashtra 400093, India Email - vishal.bhavsar@adityabirla.com	
Product	Ordinary Portland Cement (OPC), Pozzolana Portland Cement (PPC), Portland Slag Cement (PSC) and Portland Composite Cement (PCC)	
CPC Code	3744	
EPD registration number	S-P-05019	
Publication date	2022-08-02	
Validity date	2027-08-01	
Geographical scope	Worldwide	
Reference standards	ISO 14020:2001, ISO 14025:2006, EN 15804:2012+A2:2019, EN 16908:2017	

Table 2-2. PCR Information

Reference PCR	'Construction Products and Construction Services'2019:14, Version 1.11 & c-PCR-001 Cement and building lime (EN 16908)
Date of Issue	2021-02-05 (Version 1.11)

Table 2-3. Verification Information

Demonstration of verification	External, independent verification
Third party verifier	Dr Hüdai Kara, Metsims Sustainability Consulting, 4 Clear Water Place, Oxford OX2 7NL, UK Email: hudai.kara@metsims.com

Table 2-4. LCA Information

Title	Environmental Product Declaration of Cement Products
Author	Dr. Rajesh Kumar Singh Thinkstep Sustainability Solutions Pvt. Ltd., a Sphera Company 707, Meadows, Sahar Plaza, Andheri Kurla Road, Andheri East, Mumbai, India - 400059 Email: rsingh@sphera.com
Reference standards	ISO 14040/44 standard

2.2 Reference Period of EPD Data

The reference period for the primary data (foreground data) used within this EPD is FY 2018-2019.The background data used in the study have been applied through GaBi datasets which are less than 5 years old.

2.3 Geographical Scope of EPD Application

The geographical scope of this EPD is global.

2.4 Additional Information about EPD

This EPD provides information for the four Cement products i.e., Ordinary Portland Cement (OPC), Pozzolana Portland Cement (PPC), Portland Slag Cement (PSC) and Portland Composite Cement (PCC) manufactured at 22 cements plants representative of UltraTech Cement Company. The EPD is in accordance with ISO 14025 and EN 15804+A2. EPD of construction products may not be comparable if they do not comply with EN 15804+A2. The Life Cycle Assessment (LCA) study carried out for developing this EPD for cement products is done as per ISO 14040 and ISO 14044 requirements.

Product Category Rules (PCR) for the assessment of the environmental performance of cement products is PCR for ‘Construction Products and Construction Services’ 2019:14, Version 1.11 & c-PCR-001 Cement and building lime (EN 16908).

This PCR is applicable to the product “Cement Product “complying with the standard EN 15804+A2 (Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products).

3. Product Description and System Boundaries

3.1 Product Description

Cement is the most essential raw material in any kind of construction activity. It is used in preparation of concrete, mortar, grout, plaster, etc. Accordingly, cement industry plays a crucial role in the infrastructural development of the country. The Table 3-1 gives the composition of all the 4 cement types.

Table 3-1 Cement composition

Composition	OPC	PPC	PSC	PCC
Clinker	92.03%	63.19%	38.00%	44.72%
Fly ash	-	33.33%	-	23.75%
Slag	-	-	60.00%	27.50%
Gypsum	3.76%	3.45%	2.00%	4.03%
Additional constituents	4.22%	0.031%	-	-

Table 3-2 provides the UltraTech cement products with their respective shares

Table 3-2. UltraTech cement products with their respective share

Cement Products	Quantity of cement produced (tonnes)	Share
OPC	1,80,46,130.53	37.22%
PPC	2,73,08,411.38	56.33%
PSC	6,13,800.93	1.27%
PCC	9,99,868.49	2.06%
Total	**4,69,68,211.33**	**96.88%**

Remaining 3.12% of the cement production consist of IRST, Export Grade, EGC PPC, SRPC cements, which are not included in the scope of the study.

1. **OPC**: Ordinary Portland Cement is the most commonly used cement for a wide range of applications, covering standard, high strength concretes, masonry and plastering works, precast concrete products for e.g., blocks, pipes etc., and specialized works such as precast and prestressed concrete.
2. **PPC**: Portland Pozzolana Cement is ordinary Portland cement intimately blended or ground with pozzolanic materials such as fly ash, calcined clay, rice husk ash etc. The concrete produced by using Portland Pozzolana cement has high ultimate strength, is more durable, resists wet cracking, thermal cracking and has a high degree of cohesion and workability in concrete and mortar.
3. **PSC**: Portland Slag Cement is a cement with high flexural strength and is suitable for infrastructure projects due to its low heat of hydration. Application ranges from high performance or high strength concrete, structures and foundations to pre-cast concrete.
4. **PCC**: Portland Composite Cement is a cement with waste products like fly ash and slag substituting the natural materials. This allows optimization of the main characteristics of cement clinker and reduction of CO2 emissions due less use of clinker and also offer considerable opportunities for optimizing properties like strength and workability.

3.2 System Boundary

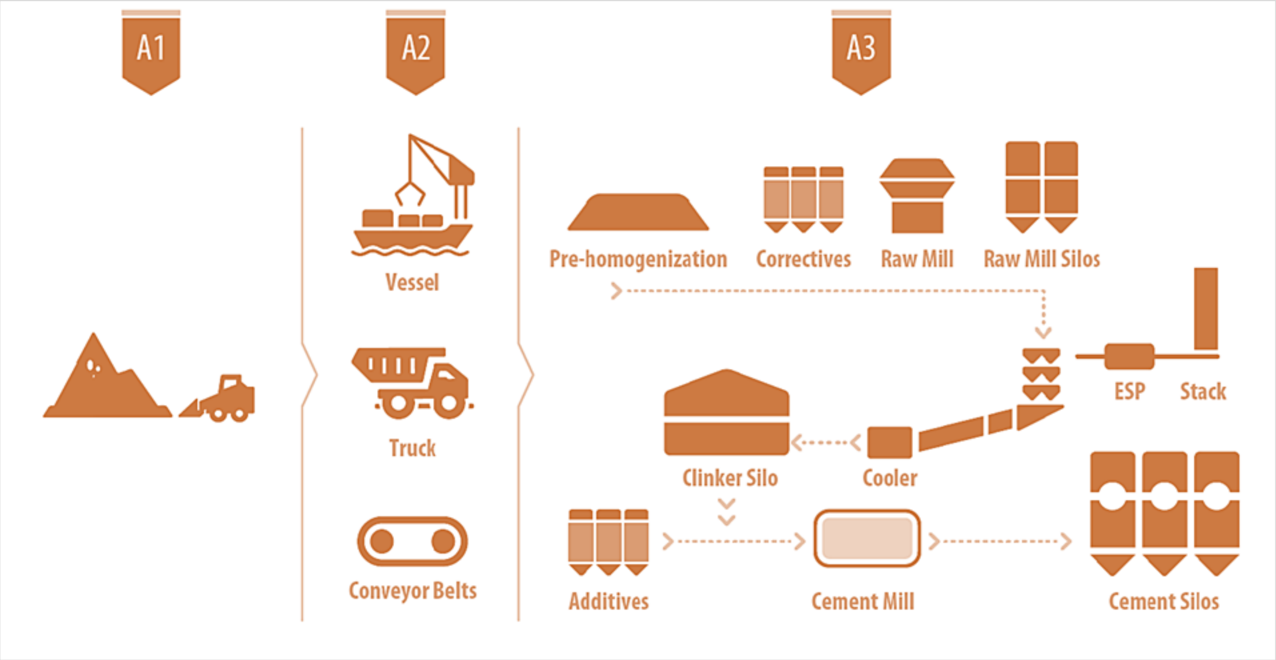


Figure 1 given below represents system boundary diagram of the study.

Figure 1 System boundary diagram

A1: Raw Material Supply
Production for each product starts with mainly locally sourced but some transported from other parts of the world. 'Raw material supply' includes raw material extraction and pretreatment processes before production.

A2: Raw Material Transport
Transport is relevant for delivery of raw materials and other materials to the plant and the transport of materials within the plant. Transport of raw materials to production site is taken as the weight average values for transport from raw materials supplier.

A3: Manufacturing
Cement production starts with quarry operation. After the crushing and homogenization process, raw materials go to the mills. Production continues with burning and cooling. Finally, additional raw materials are added to the mixture, mixed and ready for use.

4. LCA

4.1 Information Sources and Data Quality

It is important that data quality is in accordance with the requirements of the LCA's goal and scope. This is essential to the reliability of LCA and achievement of the intended application. The quality of the LCI data for modelling the life cycle stages have been assessed according to ISO 14040:2006. Data quality is judged by its precision (measured, calculated or estimated), completeness (e.g., are there unreported emissions?), consistency (degree of uniformity of the methodology applied on an LCA serving as a data source) and representativeness (geographical, time period, technology). Primary data collected using data collection questionnaires was used for the study and for upstream processes GaBi 10.5 professional database 2021 was used.

4.2 Methodological Details

4.2.1 Co-Product Allocation

No allocation has been done. As no co-products are produced, the flow of materials and energy and the associated release of substances and energy into the environment is related exclusively to the cement produced.

4.2.2 End-of-life phase

End of life phase of the product has not been considered in the study since, the product fulfills the three conditions required by EN 15804:2012+A2:2019, about the exclusion of modules C1-C4 and D.

4.2.3 Declared unit

The declared unit is a reference for the product whose lifecycle impact is being assessed. The declared unit allows quantification of the environmental impacts of cement over cradle-to-gate life cycle stage. These environmental impacts are calculated on the basis of the declared unit wherein each flow related to material consumption, energy consumption, emissions, effluent and waste is scaled to the reference flow.

The declared unit is 1000 kg each of OPC, PPC, PSC, PCC, manufactured at 22 cement plants, representative of UltraTech Cement Company and covering 67% production volume, over the 'Cradle to Gate' system boundary.

4.2.4 Selection of application of LCIA categories

A list of relevant impact categories and category indicators is defined and associated with the inventory data. The environmental impact per declared unit for the following environmental impact categories were reported in the EPD according with EN15804+A2:2019 (Table 4-1), and divided into core, upstream (and downstream, if included) module.

Table 4-1. Environmental impacts indicators for EN15804+A2:2019

Impact category	Indicator	Unit
Climate change – total	Global Warming Potential total (GWP-total)	kg CO_2 eq.
Climate change - fossil	Global Warming Potential fossil fuels (GWP-fossil)	kg CO_2 eq.
Climate change - biogenic	Global Warming Potential biogenic (GWP-biogenic)	kg CO_2 eq.
Climate change - luluc	Global Warming Potential land use and land use change (GWP-luluc)	kg CO_2 eq.
Ozone Depletion	Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 eq.
Acidification	Acidification potential, Accumulated Exceedance (AP)	Mole of H+ eq.
Eutrophication aquatic freshwater	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	kg P eq.
Eutrophication aquatic marine	Eutrophication potential, fraction of nutrients reaching marine end compartment (EP-marine)	kg N eq.
Eutrophication terrestrial	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	Mole of N eq.

Photochemical ozone formation	Formation potential of tropospheric ozone (POCP)	kg NMVOC eq.
Depletion of abiotic resources - minerals and metals	Abiotic depletion potential for non-fossil resources (ADP- minerals & metals)	kg Sb eq.
Depletion of abiotic resources - fossil fuels	Abiotic depletion for fossil resources potential (ADP-fossil)	MJ
Water use	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	m^3 world equiv.

The consumption of natural resources per declared or function unit is reported in the EPD. Input parameters, according with EN15804+A2, describing resource use are shown in Table 4-2.

Table 4-2. Natural resources use parameters

Parameter	Unit
Renewable primary energy as energy carrier (PERE)	MJ
Renewable primary energy resources as material utilization (PERM)	MJ
Total use of renewable primary energy resources (PERT)	MJ
Non-renewable primary energy as energy carrier (PENRE)	MJ
Non-renewable primary energy as material utilization (PENRM)	MJ
Total use of non-renewable primary energy resources (PENRT)	MJ
Use of secondary material (SM)	kg
Use of renewable secondary fuels (RSF)	MJ
Use of non-renewable secondary fuels (NRSF)	MJ
Net freshwater Use (FW)	m^3

Table 4-3. Output flows and waste categories parameters

Parameter	Unit
Hazardous waste disposed (HWD)	kg
Non-hazardous waste disposed (NHWD)	kg
Radioactive waste disposed (RWD)	kg
Components for re-use (CRU)	kg
Materials for recycling (MFR)	kg
Materials for energy recovery (MER)	kg
Exported electrical energy (EEE)	MJ
Exported thermal energy (EET)	MJ

Table 4-4. Additional parameters

Impact category	Indicator	Unit
Particulate matter emissions	Potential incidence of disease due to PM emissions (PM)	Disease incidences

Ionising radiation	Potential Human exposure efficiency relative to U235 (IRP)	kBq U235 eq.
Eco-toxicity (freshwater)	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	CTUe
Human toxicity, cancer effects	Potential Comparative Toxic Unit for humans (HTP-c)	CTUh
Human toxicity, non-cancer effects	Potential Comparative Toxic Unit for humans (HTP-nc)	CTUh
Land use related impacts/ Soil quality potential	Potential soil quality index (SQP)	Pt

4.3 Cut-off Criteria

Criteria were set out in the original study for the recording of material flows and to avoid the need to pursue trivial inputs/outputs in the system. These are outlined below:

1. All energetic inputs to the process stages were recorded, including heating fuels and electricity.

2. The sum of the excluded material flows must not exceed 5% of mass, energy, or environmental relevance. However, in reality at least 99.9% of material inputs to each process stage were included.

3. Wastes representing less than 1% of total waste tonnage for given process stages were not recorded unless treated outside of the site.

4.4 System Boundaries

The scope of this study is "Cradle to gate" covering the product stage (modules A1-A3), since the product fulfills the three conditions required by EN 15804:2012+A2:2019, about the exclusion of modules C1-C4 and D. The scope covers the ecological information to be divided into raw material production (A1), inbound transportation (A2) and Manufacturing (A3).

Table 4-5. Details of system boundary included in the study

EPD Module	Life Cycle Stages	Life Cycle Sub-Stages	Definitions
A1	Materials	Primary raw materials Production	Extraction and production of raw materials such as limestone.
A2	Upstream Transport	Rail and road transport	Electricity from all sources (import from grid, captive power generation, DG set), energy, water and raw materials used in the production of cement

A3	Manufacturing	Raw meal preparation	Transport of raw materials for the preparation of raw meal and clinker production & cement production.
		Clinker production at 22 plants of UltraTech Cement Limited	Production of clinker using raw meal, limestone and other raw materials.
			Combustion of primary as well as secondary fuel for clinker production.
		Cement Grinding at all the 27 plants of UltraTech Cement Limited	Grinding of fly ash, slag, gypsum, grinding aid and other additives with different proportions of clinker to form cement.
			Effluent discharges (hazardous and non-hazardous) and solid waste disposal.

4.4.1 Geographic System Boundaries

The geographical coverage of this study covers the production of 4 cement products in 22 plants in India and 2 plants in United Arab Emirates (Ajman and Abu Dhabi). Imported raw materials are considered along with transport. All the primary data has been collected from UltraTech Cement Ltd in cooperation with experts from Sphera (formerly Thinkstep AG).

4.4.2 Temporal System Boundaries

The data collection is related to one year of operation and the year of the data is indicated in the questionnaire for each data point. The data was derived for the FY 2018-2019.

4.4.3 Technology coverage

The exact technological configuration was used for the various process's operation of the plants for efficient performance in production and minimizing environmental impacts. It was assumed that secondary data from databases that were used for this assessment, were temporally and technologically comparable to that of primary data and within the temporal coverage already addressed.

4.5 Software and database

The LCA model was created using the GaBi 10.5 Software system for life cycle engineering, developed by Sphera Solutions Inc. The GaBi database provides the life cycle inventory data for several of the raw and process materials obtained from the upstream system. Detailed database documentation for GaBi datasets can be accessed at https://gabi.sphera.com/international/support/gabi/gabi-database-2021-lci-documentation.

4.6 Comparability

According to the standards, EPDs do not compare the environmental performance of products in the sector. Any comparison of the declared environmental performance of products lies outside the scope of these standards and is suggested to be feasible only if all compared declarations follow equal standard provisions.

4.7 Results

Modules of the life cycle included as per PCR is given in Table 4-6.

Table 4-6. Modules of the production life cycle included (X = declared module; MND = module not declared)

Production			Installation		Use stage							End-of-Life				Credits & charges outside system boundary
Raw material supply	Transport to manufacturer	Manufacturing	Transport to building site	Installation into building	Use / application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to EoL	Waste processing for reuse, recovery, recycle	Disposal	Reuse, recovery, or recycling potential
A1	A2	A3	A4	A5	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

The scope of this study is "Cradle to gate" covering the product stage (modules A1-A3), since the product fulfills the three conditions required by EN 15804:2012+A2:2019, about the exclusion of modules C1-C4 and D. The scope covers the ecological information to be divided into raw material production (A1), inbound transportation (A2) and Manufacturing (A3).

4.7.1 LCIA results for 1- tonne of Ordinary Portland Cement (OPC)

The LCIA results for 1 tonne of OPC are given in Table 4-7 to Table 4-10.

Table 4-7: Environmental impacts for 1 tonne of OPC

Parameters	Unit	A1- A3
GWP - total	kg CO_2 eq.	9.96E+02
GWP - fossil	kg CO_2 eq.	9.90E+02
GWP - biogenic	kg CO_2 eq.	5.07E+00
GWP - luluc	kg CO_2 eq.	3.13E-02
ODP	kg CFC-11 eq.	1.53E-10
AP	Mole of H+ eq.	3.58E+00
EP - freshwater	kg P eq.	1.27E-04
EP – freshwater*	kg Phosphate eq.	3.91E-04
EP - marine	kg N eq.	1.04E+00
EP - terrestrial	Mole of N eq.	1.15E+01
POCP	kg NMVOC eq.	2.84E+00
ADPE	kg Sb eq.	9.80E-06
ADPF	MJ	5.95E+03
WDP	m^3 world equiv.	8.58E+00
Caption	GWP - total = global warming potential; GWP - fossil = global warming potential (fossil fuel only); GWP - biogenic = global warming potential (biogenic); GWP - luluc = global warming potential (land use only); ODP = ozone depletion; AP = acidification terrestrial and freshwater; EP - freshwater = eutrophication potential (freshwater); EP - marine = eutrophication potential (marine); EP- terrestrial = eutrophication potential (terrestrial); POCP = photochemical ozone formation; ADPE = abiotic depletion potential (element), ADPF = abiotic depletion potential	

	(fossil) WDP = water scarcity.

**"Disclaimer: EP-freshwater indicator has also been calculated as "kg P eq" as required in the characterization model (EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe; http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml) in addition to "kg PO4 eq." as stated in the standard".*

Table 4-8. Resource use for 1-tonne of OPC

Parameters	Unit	A1- A3
PERE	MJ	7.75E+01
PERM	MJ	0.00E+00
PERT	MJ	7.75E+01
PENRE	MJ	5.96E+03
PENRM	MJ	0.00E+00
PENRT	MJ	5.96E+03
SM	kg	3.18E+01
RSF	MJ	2.03E+01
NRSF	MJ	5.52E+01
FW	m3	2.70E-01
Caption	PERE = Use of renewable primary energy as energy carrier; PERM = Use of renewable primary energy as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy as energy carrier; PENRM = Use of non-renewable primary energy as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water	

Table 4-9: Output flows and waste categories for 1-tonne of OPC

Parameters	Unit	A1- A3
HWD	kg	4.86E-08
NHWD	kg	3.73E-01
RWD	kg	0.00E+00
CRU	kg	0.00E+00
MFR	kg	0.00E+00
MER	kg	0.00E+00
EEE	MJ	0.00E+00
EET	MJ	0.00E+00
Caption	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy	

Table 4-10: Additional Environmental parameters for 1-tonne of OPC

Parameters	Unit	A1- A3
PM	Disease incidences	4.52E-05
IR	kBq U235 eq.	4.68E-01
ETF-fw	CTUe	1.85E+03
HTP-c	CTUh	5.50E-08
HTP-nc	CTUh	3.49E-06
SQP	Pt	6.14E+01
Caption	PM = Particulate matter emissions; IR = Ionizing radiation, human health; ETF-fw = Eco-toxicity (freshwater); HTP-c = Human toxicity, cancer effects; HTP-nc = Human toxicity, non-cancer effects, SQP = Soil quality potential/ Land use related impacts	

4.7.2 LCIA results for 1- tonne of Pozzolana Portland Cement (PPC)

The LCIA results for 1 tonne of PPC are given in Table *4-11* to Table 4-14.

Table 4-11. Environmental impacts for 1-tonne of PPC

Parameters	Unit	A1- A3
GWP - total	kg CO_2 eq.	7.10E+02
GWP - fossil	kg CO_2 eq.	7.06E+02
GWP - biogenic	kg CO_2 eq.	3.72E+00
GWP - luluc	kg CO_2 eq.	2.44E-02
ODP	kg CFC-11 eq.	1.14E-10
AP	Mole of H+ eq.	2.72E+00
EP - freshwater	kg P eq.	9.24E-05
EP – freshwater*	kg Phosphate eq.	2.84E-04
EP - marine	kg N eq.	7.65E-01
EP - terrestrial	Mole of N eq.	8.45E+00
POCP	kg NMVOC eq.	2.09E+00
ADPE	kg Sb eq.	7.27E-06
ADPF	MJ	4.44E+03
WDP	m^3 world equiv.	6.82E+00
Caption	GWP - total = global warming potential; GWP - fossil = global warming potential (fossil fuel only); GWP - biogenic = global warming potential (biogenic); GWP - luluc = global warming potential (land use only); ODP = ozone depletion; AP = acidification terrestrial and freshwater; EP - freshwater = eutrophication potential (freshwater); EP - marine = eutrophication potential (marine); EP- terrestrial = eutrophication potential (terrestrial); POCP = photochemical ozone formation; ADPE = abiotic depletion potential (element), ADPF = abiotic depletion potential (fossil) WDP = water scarcity.	

Table 4-12. Resource use for 1-tonne of PPC

Parameters	Unit	A1- A3
PERE	MJ	5.96E+01
PERM	MJ	0.00E+00
PERT	MJ	5.96E+01
PENRE	MJ	4.44E+03
PENRM	MJ	0.00E+00
PENRT	MJ	4.44E+03
SM	kg	3.55E+02
RSF	MJ	1.39E+01
NRSF	MJ	3.79E+01
FW	m3	2.17E-01
Caption	PERE = Use of renewable primary energy as energy carrier; PERM = Use of renewable primary energy as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy as energy carrier; PENRM = Use of non-renewable primary energy as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water	

Table 4-13: Output flows and waste categories for 1-tonne of PPC

Parameters	Unit	A1- A3
HWD	kg	3.85E-08
NHWD	kg	2.85E-01
RWD	kg	0.00E+00
CRU	kg	0.00E+00
MFR	kg	0.00E+00
MER	kg	0.00E+00
EEE	MJ	0.00E+00
EET	MJ	0.00E+00
Caption	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy	

Table 4-14: Additional Environmental parameters for 1-tonne of PPC

Parameters	Unit	A1- A3
PM	Disease incidences	3.48E-05
IR	kBq U235 eq.	3.52E-01
ETF-fw	CTUe	1.38E+03
HTP-c	CTUh	4.09E-08
HTP-nc	CTUh	2.49E-06
SQP	Pt	4.64E+01
Caption	PM = Particulate matter emissions; IR = Ionizing radiation, human health; ETF-fw = Eco-toxicity (freshwater); HTP-c = Human toxicity, cancer effects; HTP-nc = Human toxicity, non-cancer effects, SQP = Soil quality potential/ Land use related impacts	

4.7.3 LCIA results for 1- tonne of Portland Slag Cement (PSC)

The LCIA results for 1 tonne of PSC are given in Table 4-15 to Table 4-18.

Table 4-15: Environmental impacts for 1-tonne of PSC

Parameters	Unit	A1- A3
GWP - total	kg CO_2 eq.	4.87E+02
GWP - fossil	kg CO_2 eq.	4.85E+02
GWP - biogenic	kg CO_2 eq.	2.62E+00
GWP - luluc	kg CO_2 eq.	1.73E-02
ODP	kg CFC-11 eq.	8.00E-11
AP	Mole of H+ eq.	2.98E+00
EP - freshwater	kg P eq.	6.53E-05
EP – freshwater*	kg Phosphate eq.	2.00E-04
EP - marine	kg N eq.	7.85E-01
EP - terrestrial	Mole of N eq.	8.64E+00
POCP	kg NMVOC eq.	2.16E+00
ADPE	kg Sb eq.	5.58E-06
ADPF	MJ	3.48E+03
WDP	m^3 world equiv.	5.30E+00

Caption	GWP - total = global warming potential; GWP - fossil = global warming potential (fossil fuel only); GWP - biogenic = global warming potential (biogenic); GWP - luluc = global warming potential (land use only); ODP = ozone depletion; AP = acidification terrestrial and freshwater; EP - freshwater = eutrophication potential (freshwater); EP - marine = eutrophication potential (marine); EP- terrestrial = eutrophication potential (terrestrial); POCP = photochemical ozone formation; ADPE = abiotic depletion potential (element), ADPF = abiotic depletion potential (fossil) WDP = water scarcity.

Table 4-16. Resource use for 1-tonne of PSC

Parameters	Unit	A1- A3
PERE	MJ	4.36E+01
PERM	MJ	0.00E+00
PERT	MJ	4.36E+01
PENRE	MJ	3.48E+03
PENRM	MJ	0.00E+00
PENRT	MJ	3.48E+03
SM	kg	6.21E+02
RSF	MJ	1.31E+01
NRSF	MJ	3.56E+01
FW	m3	1.66E-01
Caption	PERE = Use of renewable primary energy as energy carrier; PERM = Use of renewable primary energy as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy as energy carrier; PENRM = Use of non-renewable primary energy as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water	

Table 4-17: Output flows and waste categories for 1-tonne of PSC

Parameters	Unit	A1- A3
HWD	kg	2.94E-08
NHWD	kg	2.09E-01
RWD	kg	0.00E+00
CRU	kg	0.00E+00
MFR	kg	0.00E+00
MER	kg	0.00E+00
EEE	MJ	0.00E+00
EET	MJ	0.00E+00
Caption	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy	

Table 4-18: Additional Environmental parameters for 1-tonne of PSC

Parameters	Unit	A1- A3
PM	Disease incidences	4.26E-05
IR	kBq U235 eq.	2.55E-01
ETF-fw	CTUe	1.09E+03
HTP-c	CTUh	3.05E-08
HTP-nc	CTUh	1.70E-06
SQP	Pt	3.38E+01

Caption	PM = Particulate matter emissions; IR = Ionizing radiation, human health; ETF-fw = Eco-toxicity (freshwater); HTP-c = Human toxicity, cancer effects; HTP-nc = Human toxicity, non-cancer effects, SQP = Soil quality potential/ Land use related impacts

4.7.4 LCIA results for 1- tonne of Portland Composite Cement (PCC)

The LCIA result for 1 tonne of PCC are given in Table *4-19* to Table *4-22*.

Table 4-19. Environmental impacts for 1-tonne of PCC

Parameters	Unit	A1- A3
GWP - total	kg CO_2 eq.	5.41E+02
GWP - fossil	kg CO_2 eq.	5.38E+02
GWP - biogenic	kg CO_2 eq.	2.92E+00
GWP - luluc	kg CO_2 eq.	2.16E-02
ODP	kg CFC-11 eq.	8.91E-11
AP	Mole of H+ eq.	2.64E+00
EP - freshwater	kg P eq.	7.27E-05
EP – freshwater*	kg Phosphate eq.	2.23E-04
EP - marine	kg N eq.	7.10E-01
EP - terrestrial	Mole of N eq.	7.82E+00
POCP	kg NMVOC eq.	1.95E+00
ADPE	kg Sb eq.	5.96E-06
ADPF	MJ	3.66E+03
WDP	m^3 world equiv.	5.78E+00
Caption	GWP - total = global warming potential; GWP - fossil = global warming potential (fossil fuel only); GWP - biogenic = global warming potential (biogenic); GWP - luluc = global warming potential (land use only); ODP = ozone depletion; AP = acidification terrestrial and freshwater; EP - freshwater = eutrophication potential (freshwater); EP - marine = eutrophication potential (marine); EP- terrestrial = eutrophication potential (terrestrial); POCP = photochemical ozone formation; ADPE = abiotic depletion potential (element), ADPF = abiotic depletion potential (fossil) WDP = water scarcity.	

Table 4-20. Resource use for 1-tonne of PCC

Parameters	Unit	A1- A3
PERE	MJ	5.00E+01
PERM	MJ	0.00E+00
PERT	MJ	5.00E+01
PENRE	MJ	3.66E+03
PENRM	MJ	0.00E+00
PENRT	MJ	3.66E+03
SM	kg	5.28E+02
RSF	MJ	9.86E+00
NRSF	MJ	2.68E+01
FW	m3	1.90E-01
Caption	PERE = Use of renewable primary energy as energy carrier; PERM = Use of renewable primary energy as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy as energy carrier; PENRM = Use of non-renewable primary energy as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water	

Table 4-21: Output flows and waste categories for 1-tonne of PCC

Parameters	Unit	A1- A3
HWD	kg	3.35E-08
NHWD	kg	2.34E-01
RWD	kg	0.00E+00
CRU	kg	0.00E+00
MFR	kg	0.00E+00
MER	kg	0.00E+00
EEE	MJ	0.00E+00
EET	MJ	0.00E+00
Caption	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy	

Table 4-22: Additional Environmental parameters for 1-tonne of PCC

Parameters	Unit	A1- A3
PM	Disease incidences	3.59E-05
IR	kBq U235 eq.	2.84E-01
ETF-fw	CTUe	1.14E+03
HTP-c	CTUh	3.31E-08
HTP-nc	CTUh	1.89E-06
SQP	Pt	3.81E+01
Caption	PM = Particulate matter emissions; IR = Ionizing radiation, human health; ETF-fw = Eco-toxicity (freshwater); HTP-c = Human toxicity, cancer effects; HTP-nc = Human toxicity, non-cancer effects, SQP = Soil quality potential/ Land use related impacts	

4.8 Interpretation

The interpretation of the results for 1-tonne of cement products (OPC, PPC, PSC, PCC) are presented in Table *4-23* - Table *4-26*.

Table 4-23. Interpretation of most significant contributors to life cycle parameters (1-tonne OPC)

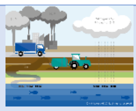
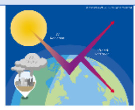
Parameter		Most significant contributor
Abiotic Depletion Potential (ADP) - Elements		The total cradle to gate impact is 9.80E-06 kg Sb eq. In A1 – A3 module more than 98.00% impact is due to the gypsum used in grinding process.
Acidification Potential (AP)		The total cradle to gate impact is 3.58 Mole of H+ eq. In A1 – A3, the major contribution is from clinker production (35.90%) and clinker transportation (39.40%).
Eutrophication Potential (EP)		The total cradle to gate impact is 1.27E-04 kg P eq. In A1 – A3, the major contribution is from clinker production (47.50%) followed by clinker transportation (41.60%).
Global Warming Potential (GWP 100 years)		The total cradle to gate impact is 995.560 kg CO_2 eq. In A1 – A3, major contribution is from clinker production (81.01%).
Ozone Layer Depletion Potential (ODP, steady state)		The total cradle to gate impact is 1.53E-10 kg CFC-11 eq. In module A1 – A3, the impacts are due to the bauxite consumption in raw meal preparation.
Photochemical Ozone Creation Potential (POCP)		The total cradle to gate impact is 2.84 kg NMVOC eq. In module A1 – A3, major contribution from clinker production (61.10%) and clinker transport (11.60%).
Abiotic depletion potential (ADP) - Fossil		The total cradle to gate impact is 5952.77 MJ. In A1- A3 module, the major contribution is from clinker production (57.40%) and clinker transport (17.20%).

Table 4-24: Interpretation of most significant contributors to life cycle parameters (1-tonne PPC)

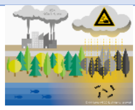
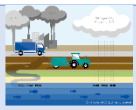
Parameter		Most significant contributor
Abiotic Depletion Potential (ADP) - Elements		The total cradle to gate impact is 7.27E-06 kg Sb eq. In A1 – A3 module more than 98.00% impact is due to the gypsum used in grinding process.
Acidification Potential (AP)		The total cradle to gate impact is 2.72 Mole of H+ eq. In A1 – A3, the major contribution is from clinker production (32.30%) followed by clinker transportation (35.40%).
Eutrophication Potential (EP)		The total cradle to gate impact is 9.24E-05 kg P eq. In A1 – A3, the major contribution is from clinker production (44.50%) followed by clinker transportation (39.00%).
Global Warming Potential (GWP 100 years)		The total cradle to gate impact is 709.547 kg CO_2 eq. In A1 – A3, major contribution is from clinker production (78.10%).
Ozone Layer Depletion Potential (ODP, steady state)		The total cradle to gate impact is 1.14E-10 kg CFC-11 eq. In module A1 – A3, the impacts are due to the bauxite consumption in raw meal preparation.
Photochemical Ozone Creation Potential (POCP)		The total cradle to gate impact is 2.09 kg NMVOC eq. In module A1 – A3, major contribution is from clinker production (56.90%) and clinker transport (10.80%).
Abiotic depletion potential (ADP) - Fossil		The total cradle to gate impact is 4440.60 MJ. In A1- A3 module, major contribution is from clinker production (52.90%) and the clinker transport (15.80%).

Table 4-25: Interpretation of most significant contributors to life cycle parameters (1-tonne PSC)

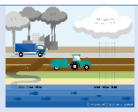
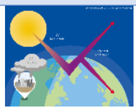
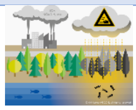
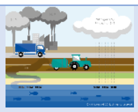
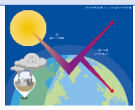
Parameter		Most significant contributor
Abiotic Depletion Potential (ADP) - Elements		The total cradle to gate impact is 5.58E-06 kg Sb eq. In A1 – A3 module more than 98.00% impact is due to the gypsum used in grinding process.
Acidification Potential (AP)		The total cradle to gate impact is 2.98 Mole of H+ eq. In A1 – A3, the major contribution is from cement griding (30.50%), clinker production (25.30%) and clinker transportation (27.80%).
Eutrophication Potential (EP)		The total cradle to gate impact is 6.53E-05 kg P eq. In A1 – A3, the major contribution is from clinker production (35.80%) followed by clinker transportation (31.40%) and cement grinding (26.20).
Global Warming Potential (GWP 100 years)		The total cradle to gate impact is 487.456 kg CO_2 eq. In A1 – A3, major contribution is from clinker production (75.70%).
Ozone Layer Depletion Potential (ODP, steady state)		The total cradle to gate impact is 8.00E-11 kg CFC-11 eq. In module A1 – A3, the impacts are due to the bauxite consumption in raw meal preparation.
Photochemical Ozone Creation Potential (POCP)		The total cradle to gate impact is 2.16 kg NMVOC eq. In module A1 – A3, major contribution from clinker production (42.20%) and cement grinding process (30.00%).
Abiotic depletion potential (ADP) - Fossil		The total cradle to gate impact is 3478.14 MJ. In A1- A3 module, major contribution is from clinker production (49.50%) followed by cement grinding (18.60%) and clinker transport (14.80%).

Table 4-26: Interpretation of most significant contributors to life cycle parameters (1-tonne PCC)

Parameter		Most significant contributor
Abiotic Depletion Potential (ADP) - Elements		The total cradle to gate impact is 5.96E-06 kg Sb eq. In A1 – A3 module more than 98.00% impact is due to the gypsum used in grinding process.
Acidification Potential (AP)		The total cradle to gate impact is 2.64 Mole of H+ eq. In A1 – A3, the major contribution is from cement griding (32.60%), clinker production (23.50%) and clinker transportation (25.80%).
Eutrophication Potential (EP)		The total cradle to gate impact is 7.27E-05 kg P eq. In A1 – A3, the major contribution is from clinker production (34.10%) followed by clinker transportation (29.90%) and cement grinding (28.80%).
Global Warming Potential (GWP 100 years)		The total cradle to gate impact is 540.793 kg CO_2 eq. In A1 – A3, major contribution is from clinker production (72.20%).
Ozone Layer Depletion Potential (ODP, steady state)		The total cradle to gate impact is 8.91E-11 kg CFC-11 eq. In module A1 – A3, the impacts are due to the bauxite consumption in raw meal preparation.
Photochemical Ozone Creation Potential (POCP)		The total cradle to gate impact is 1.95 kg NMVOC eq. In module A1 – A3, major contribution is from clinker production (40.70%) and cement grinding process (28.40%).
Abiotic depletion potential (ADP) - Fossil		The total cradle to gate impact is 3659.40 MJ. In A1- A3 module, major contribution is from clinker production (45.50%) and cement grinding (22.80%).

Concluding, the study provides fair understanding of environmental impacts during the various life cycle stages of cement production. It also identifies the hot spots in the value chain where improvement activities can be prioritised and accordingly investment can be planned. The scope covers the ecological information to be divided into raw material production (A1), transportation (A2) and Manufacturing (A3).

5. LCA Terminology

Cradle to Gate	Scope of study extends from mining of natural resources to the completed product ready for shipping from the manufacturing dispatch "gate", known as Modules A1-A3.
Cradle to Grave	Scope of study extends from mining of natural resources to manufacture, use and disposal of products at End of Life, including all Modules A-D.
End of life	Post-use phase life cycle stages involving collection and processing of materials (e.g., scrap) and recycling or disposal, known as Modules C and D.

6. Other Environmental Information

The constituent materials used within our products are responsibly sourced and we apply the principles of Sustainable Development and of Environmental Stewardship as a standard business practice in our operations. Protecting the environment by preserving non-renewable natural resources, increasing energy efficiency, reducing the environmental emissions, limiting the impact of materials transportation to and from our operations is part of our way in doing business.

Products do not contain any substances that can be included in "Candidate List of Substances of Very High Concern for Authorization" and raw materials used are not part of the EU REACH regulation.

7. References

- EN 15804: 2012+A2:2019, Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products
- EVS-EN 16908:2017, Sub-PCR Cement and building lime- Environmental product declarations-Product category rules complementary to EN 15804. (Estonian Centre for Standardization)
- GaBi 10 2021: Dokumentation der GaBi-Datensätze der Datenbank zur Ganzheitlichen Bilanzierung. LBP, Universität Stuttgart und PE International, 2012
- GaBi 10 2021: Software und Datenbank zur Ganzheitlichen Bilanzierung. LBP, Universität Stuttgart und PE International, 2012
- ISO 14020:2000 Environmental labels and declarations - General principles
- ISO 14025:2006 Environmental labels and declarations - Type III environmental declarations - Principles and procedures
- ISO 14040:2006 Environmental management- Life cycle assessment - Principles and framework
- ISO 14044:2006 Environmental management - Life cycle assessment - Requirements and guidelines.
- ISO 21930:2007 Sustainability in Building Construction - Environmental Declaration of Building Products.