Environmental Product Declaration of Average PPC and Compocem Cement

Ambuja Cements Limited

June 2018

ISO 14020:2001, IS0 14025:2006, ISO 14040:2006,
EN 15804:2012, EN 16908:2017

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Geographical scope:	India

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1. Introduction

This current declaration aims to provide the measurable and verifiable effects for the environmental assessment of 1000 kg of average PPC cement and Compocem cement manufactured at all the 13 cement plants of Ambuja Cements Limited. Currently, Ambuja Cement has a cement capacity of 29.65 million tons with five integrated cement manufacturing plants and eight cement grinding units across the country.

Ambuja Cements Limited is India's foremost manufacturer of cement and ready mixed concrete with modern cement plants. The company has a significant presence across India as a brand for Portland Pozzolana Cement (PPC - IS 1489(Part I):2015) and Compocem (IS 16415:2015). The company has been a trendsetter and noted benchmark in cement and concrete technology since it was established in 1983.

The company continuously explores ways to make its business more planet-friendly and this concern is integrated into all activities of the value chain from mining to sales. It has among the lowest carbon footprints in its class. The company has been certified five times water positive, a feat achieved through conservation efforts and increasing water efficiency in its plants. It is also plastic positive, by burning as much as over 50,000 tons of plastic waste in its kilns, equivalent to 1.54 times of total plastic used. The company also generates 6.5% of its energy from renewable resources. Ambuja Cements Limited plants, mines and townships visibly demonstrate successful endeavors in quarry rehabilitation, water management techniques and ‘greening’ activities. The company actively promotes the use of alternative fuels and resources and offers effective solutions for waste management including testing and co-processing.

2. General Information

2.1 EPD, PCR, LCA Information

Table 1. EPD Information

Programme	The International EPD® System, www.environdec.com
Program operator	EPD International AB Box 210 60, SE- 100 31 Stockholm, Sweden.
Declaration holder	Mr. Sandeep Shrivastava Ambuja Cements Limited (Research & Development Centre) 228, Udyog Vihar, Phase I, Gurgaon, PIN:122016, Haryana, India Email: sandeeps.shrivastava@ambujacement.com
Product	Cement: PPC - IS 1489(Part I):2015, Compocem - IS 16415:2015
Reference standards	IS0 14020:2001, ISO 14025:2006, ISO 21930:2007, EN 15804:2012, EN 16908:2017

Table 2. PCR Information

Reference PCR	PCR 2012-01 v2.2	EN 16908:2017
Date of Issue	May 2017	February 2017

Table 3: Verification Information

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

Table 4. LCA Information

Title	Environmental Product Declaration of Average Cement
Preparer	Dr. Rajesh Kumar Singh Thinkstep Sustainability Solutions Pvt. Ltd. 421, MIDAS, Sahar Plaza, Andheri Kurla Road, Andheri East, Mumbai, India - 400059 Email: rajesh.singh@thinkstep.com
Reference standards	ISO 14040/44 standard

2.2 Reference Period of EPD Data
The reference period for the data used for PPC and Compocem within this EPD is the year 2016 and 2017 respectively.

2.3 Geographical Scope of EPD Application
The geographical scope of this EPD is India.

2.4 Additional Information about EPD
Ambuja Cements Limited manufactures Portland Pozzolana Cement (PPC - IS 1489(Part I):2015) at 13 plants and Compocem (IS 16415:2015) at 1 Cement plant. The target group of EPD are Green Building Certification Program holders and consultants, customers, project developers, statutory agencies and government.

This EPD is in accordance with ISO 14025 and EN 15804. EPD of construction products may not be comparable if they do not comply with EN 15804. Product Category Rules (PCR) for the assessment of the environmental performance of cement is PCR 2012:01, Construction Products and Construction Services, v.2.2. and EN 16908:2017, sub-PCR Cement and Building Lime. These PCR is applicable to the product 'cement' complying with the standard EN 197-1 (composition, specifications and conformity criteria for common cements).

The environmental impacts are calculated on the basis of the functional unit wherein each flow related to material consumption, energy consumption, emissions, effluent and waste is scaled to the reference flow.

The processes listed below for the production of the final product including primary packaging is included. The processes which are mandatory to be included in plant operation (i.e. clinker production and cement production), in particular are:

- Raw material production (mining and crushing)
- Raw meal preparation
- Clinker production
- Grinding of cement
- Packaging.

The manufacturing of buildings, other capital goods and plant dismantling are not included. Inbound transportation of raw materials and fuel are included and outbound transportation of cement product is not included as per PCR.

3. Product Description and System Boundaries

3.1 Product Identification and Usage
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 present declaration is conducted for 1000 kg of average PPC Cement and Compocem cement manufactured at plants of Ambuja Cements Limited.

CPC Code of the product is 374 - Plasters, Lime and Cement.

Table 4. Cement identification and usage

Cement type (product standard)	PPC	Compocem
Significant characteristic	High strength, long-term strength	higher superior early strength, eco-friendly, sustainable product
Application domain	Plastering under aggressive conditions, binder for concrete and mortar	For long-term strength and durable concrete.
Market segment	Hydraulic structures, Mass concreting works Marine structures, Masonry mortars.	High rise building, Sewage treatments works, Water treatment plants.

Table 5. Cement composition

Composition	PPC	Compocem
Clinker	65%	50%
Fly ash	26-32%	23%
Gypsum	4-5%	3%
Minor additional constituents	0-6%	0-1%
BF Slag	-	23%

3.2 Product Manufacturing

The main steps in cement manufacturing process are:

3.2.1 Raw material production (mining and crushing)

Cement uses raw materials that cover calcium, silica, iron and aluminum. Such raw materials are limestone, clay and sand. Limestone is for calcium. It is combined with much smaller proportions of sand and clay. Sand and clay fulfill the need of silicon, iron and aluminum. Limestone is excavated from open cast mines after drilling and blasting and loaded onto dumpers which transport the material and unload into hoppers of the limestone crushers.

3.2.2 Raw meal preparation (grinding, proportioning and blending)

Following extraction of the raw materials, they are crushed and milled into fine powders. These powders are tested and blended to produce a final blend, known as 'raw meal' with a precise chemical composition. After final grinding, the material is ready to face the pre-heating chamber. Pre-heater chamber consists of series of vertical cyclone from where the raw material passes before facing the kiln. Pre-heating chamber utilizes the emitting hot gases from kiln. Pre-heating of the material saves the energy and make plant environmental friendly. The raw meal is pre-heated to temperature in excess of 900°C using the hot gases from the kiln.

3.2.3 Clinker production

Clinker is produced in a rotary kiln, which is a cylindrical steel shell, lined with refractory bricks. The kiln is inclined at 3% and set rotating at a speed of 2 to 2.2 rpm. The raw mix or corrected slurry is injected into the kiln from its upper end. Burning fuel like powdered coal or petcoke or oil or hot gases are forced through the lower end of the kiln and hot flame is produced. Due to inclined position and slow rotation of the kiln, the material charged from upper end is moving towards lower end (hottest zone) at a speed of 15 meter/hour. As it gradually descends, the temperature rises. In the upper part, water or moisture in the material is evaporated at 400°C temperature, therefore it is known as drying zone.

In the central part (calcination zone), temperature is around 1000°C, where decomposition of limestone takes place. After the escape of CO_2, the remaining material form small lumps called nodules.

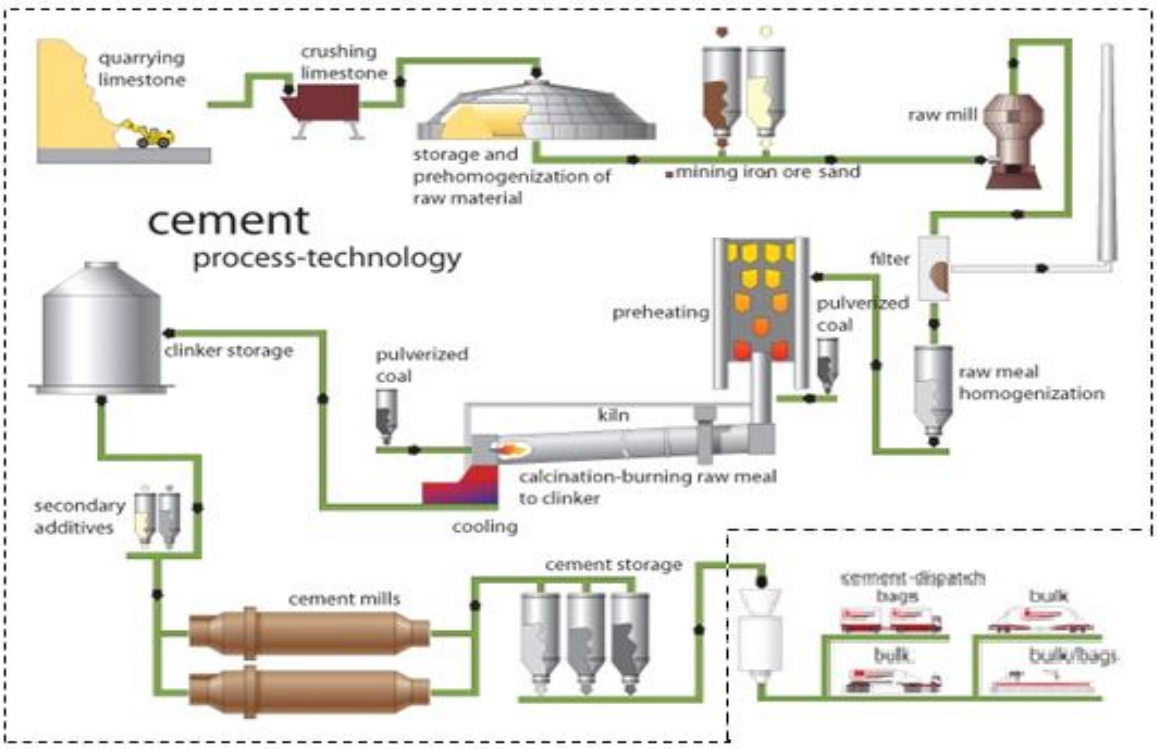

Figure 1: System boundary for the LCA study (A1, A2, A3)

$$CaCO_3 \rightarrow CaO + CO_2$$

The lower part (clinkering zone) have temperature in between 1500-1700°C, where lime and clay react to yield calcium aluminates and calcium silicates. This aluminates and silicates of calcium fuse together to form small and hard stones, known as clinker. The size of the clinker varies from 5-10 mm.

$$2CaO + SiO_2 \rightarrow Ca_2SiO_4 \text{ (dicalcium silicate } (C_2S))$$

$$3CaO + SiO_2 \rightarrow Ca_3SiO_5 \text{ (tricalcium silicate } (C_3S))$$

$$3CaO + Al_2O_3 \rightarrow Ca_3Al_2O_6 \text{ (dicalcium aluminate } (C_2A))$$

$$4CaO + Al_2O_3 + Fe_2O_3 \rightarrow Ca_4Al_2Fe_2O_{10} \text{ (tetracalcium aluminoferrite } (C_4AF))$$

As clinker is coming from kiln burning zone, it is very hot. It is then immediately quenched in the clinker cooler to stabilize its properties and stored in the clinker store.

3.2.4 Grinding of Cement

The cement mill grinds the clinker to a fine powder. A small amount of gypsum - a form of calcium sulfate - is normally ground up with the clinker. The gypsum controls the setting properties of the cement when water is added. Grinding clinker and gypsum produces Ordinary Portland cement (OPC). Fly ash at required proportion is ground along with clinker and gypsum to produce Portland Pozzolana Cement (PPC). Fly ash and slag at required proportion is ground along with clinker and gypsum to produce Compocem, respectively.

3.2.5 Packaging

The cement is then stored in silos and packed in bags using packing machines

3.3 System Boundaries

The selected system boundaries comprise the production of cement including raw material extraction up to the finished product at the factory gate.

Table 6. System boundary and product stages

Module	Product stages
A1	Production of raw materials
A2	Upstream Transport (Inbound transportation)
A3	Manufacturing (Raw meal preparation, Clinker production, Cement grinding)

The system boundary does not include:

- Capital equipment and maintenance of production facility
- Maintenance and operation of support equipment
- Human labor and employee transport

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 14044 (ISO, 2006b). 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 a LCA serving as a data source) and representativeness (geographical, time period, technology). To cover these requirements and to ensure reliable results, first-hand industry data in combination with consistent, upstream LCA information is used. The datasets have been used in LCA-models worldwide for several years in industrial and scientific applications for internal as well as critically reviewed studies. In the process of providing these datasets, they have been cross-checked with other databases and values from industry and science. Ambuja Cements Limited provided the most accurate and representative data for cement production. For all data requirements, primary data were used where possible.

4.2 Estimations and Methodology

No estimations are made.

4.2.1 Allocation procedures

No allocation has been done.

4.2.2 Average cement

The inventory data of the cement produced at all the 13 plants (of which 5 plants have their own clinker production units and the remaining 8 plants cement grinding units), are used to calculate the declared average PPC cement. The average is determined based on the produced amounts by weight in the year 2016. One of the plant manufactures Compocem cement for which data has been considered for the year 2017. The environmental profile of Compocem is given in Annexure.

4.2.3 Declared unit

The declared unit for the EPD is 1000 kg of average PPC cement for 13 plants and 1000 kg of Compocem cement manufactured at 1 plant of Ambuja Cements Limited.

4.2.4 Impact assessment

A list of relevant impact categories and category indicators is defined and associated with the inventory data. Various environmental impacts and emissions are associated with production of precast concrete, from raw material production, transport of materials to manufacturing site to precast concrete production.

CML 2001 (January 2016) method developed by Institute of Environmental Sciences, Leiden University, Netherlands have been selected for evaluation of environmental impacts. These indicators are scientifically and technically valid.

A list of relevant impact categories and category indicators is defined and associated with the inventory data. EN 15804, PCR 2012:01 and EN 16908:2017 has been used to conduct the LCA. The PCR identifies the following LCI and LCIA.

1. Potential Environmental Impact (according with EN15804)
   - Global warming potential, GWP (100 years) (kg CO_2 equivalent)
   - Depletion potential of the stratospheric ozone layer, ODP (20 years) (kg CFC-11 equivalent)
   - Acidification potential of soil and water, AP (kg SO_2 equivalent)
   - Eutrophication potential, EP (kg PO_4^{3-} equivalent)
   - Formation potential of tropospheric ozone, POCP (kg Ethene (C_2H_2) equivalent)
   - Abiotic depletion potential (ADP-elements) for non-fossil resources (kg Sb equivalent)
   - Abiotic depletion potential (ADP-fossil fuels) for fossil resources (MJ, net calorific value)

2. Use of Natural Resources (according with EN15804)
   - Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)
   - Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)
   - Use of secondary material (kg)
   - Use of renewable secondary fuels (MJ, net calorific value)
   - Use of non- renewable secondary fuels (MJ, net calorific value)
   - Use of net fresh water (m^3)

3. Other Environmental Indicators
   - Components for re-use (kg)
   - Materials for recycling (kg)
   - Materials for energy recovery (kg)
   - Exported energy (MJ)
   - Hazardous waste (as defined by regional directives) disposed (kg)
   - Non-hazardous waste disposed (kg)
   - Radioactive waste disposed/stored (kg)

4.3 Cut Off Rules

Input and output data have been collected through detailed questionnaires which have been developed and refined. In practice, this means that, at least, all material flows going into the cement production processes (inputs) higher than 1% of the total mass flow (t) or higher than 1% of the total primary energy input (MJ) are part of the system and modelled in order to calculate elementary flows. All material flows leaving the product system (outputs) accounting for more than 1% of the total mass flow is part of the system. All available inputs and outputs, even below the 1% threshold, have been considered for the LCI calculation. For hazardous and toxic materials and substances the cut-off rules do not apply.

Secondary raw materials used in the production system is accounted adopting the following approach:

- The environmental impacts related to the 'previous life' is not considered.
- The processes needed to prepare the secondary raw material to the new use is considered.
- If the secondary raw material contains energy, the amount is estimated considering the gross calorific value and presented as secondary energy resource.
- If the secondary raw material does not contain energy, the quantity that enter the system is considered as secondary raw material.

4.4 Background Data

All relevant background datasets were taken from the GaBi-8 software database developed by thinkstep AG. To ensure comparability of results in the LCA, the basic data from the GaBi-8 database were used for fuel, energy, transportation and auxiliary materials.

4.5 System Boundaries

4.5.1 Technical system boundaries

The LCA model of 1000 kg of average cement represents a cradle-to-gate system, starting from raw material production (mining and crushing) and ending with the product packaging.

The system boundary and geographical scope includes:

- Extraction and production of raw materials such as limestone.
- Transport of raw materials for the preparation of raw meal and clinker production
- Preparation of raw meal
- Production of clinker using raw meal, limestone and other raw materials.
- Grinding of fly ash, slag, gypsum, grinding aid and other additives with different proportions of clinker.
- Electricity from all sources (import from grid, captive power generation, DG set), Energy, water and raw materials used in the all the above process.
- Emissions to air, effluent discharges and solid waste disposal.

Table 7. Modules of the production life cycle included (X = declared module; MND = module not declared)

Production			**Installation**		**Use stage**							**End-of-Life**				**Next product system**
Raw material supply	Transport to manufacturer	Manufacturing & Packaging	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 or recycling	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

4.5.2 Geographical system boundaries

The geographical system boundaries of the LCA cover the production of cement in India. Indian boundaries wherever possible have been adapted.

Table 8. The respective share of Ambuja cement products unit wise for PPC for disclosed averaged EPD

Location	Units	Cement production (Tons)	Share
Darlaghat	Dadri, Bhatinda, Ropar, Nalagarh, Roorkee, Darlaghat	5,454,273	28.54%
Bhatapara	Sankrail and Farakka	3,356,351	17.56%
Ambuja Nagar	Ambuja Nagar and Surat	4,122,495	21.57%
Maratha Cement Works	Maratha Cement Works	3,270,636	17.11%
Rabriyawas	Dadri and Rabriyawas	2,906,058	15.21%
Total		19,109,813	100%

Table 9. The respective share of Ambuja cement products unit wise for Compocem for disclosed averaged EPD

Location	Unit	Cement production (tons)	Share
Bhatapara	Bhatapara	155,650	100%

4.5.3 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 majority of data was derived from the period January 2016 to December 2016 for PPC and January 2017 to December 2017 for Compocem.

4.6 Comparability

The EPD is established on the basis of the EN 15804 (Core rules for the product category of construction products), PCR 2012:01 and EN 16908:2017 (sub-PCR Cement and Building Lime). According to these standards, EPDs do not compare the environmental performance of products in the construction 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

The LCIA result of overall PPC cement manufactured at all the 13 plants of Ambuja Cements Limited together is given in Table 10, Table 11,Table 12 and Table 13, calculated taking the weighted average of all the products of PPC Cement.

The individual LCIA results of all the 13 plants of Ambuja Cements Limited manufacturing PPC cement is given in annexure from 7.1 to 7.5.2

The LCIA result of Compocem Cement is given in annexure 7.5.3

Table 10.LCIA result for 1000 kg average PPC cement

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	7.83E-04
Abiotic Depletion (ADP Fossil)	MJ	3.81E+03
Acidification Potential (AP)	kg SO_2-Eq.	2.29E+00
Eutrophication Potential (EP)	kg Phosphate-Eq.	2.39E-01
Global Warming Potential (GWP)	kg CO_2-Eq.	7.60E+02
Ozone Layer Depletion Potential (ODP)	kg CFC11-Eq.	5.38E-10
Photochemical Ozone Creation Potential (POCP)	kg Ethene-Eq.	1.19E-01

Table 11.Use of natural resources for 1000 kg average PPC cement

Parameters	Unit	Module A1- A3
Renewable primary energy as energy carrier	MJ	3.60E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.60E+01
Non- renewable primary energy as energy carrier	MJ	3.83E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.83E+03
Use of secondary material	kg	3.41E+02
Use of renewable secondary fuels	MJ	2.54E+01
Use of non- renewable secondary fuels	MJ	3.13E+02
Use of net fresh water	m^3	2.22E-01

Table 12. Other indicators for 1000 kg average PPC cement

Parameters	Unit	Module A1-A3
Components for reuse	kg	0.00E+00
Materials for recycling	kg	0.00E+00
Materials for energy recovery	kg	0.00E+00
Exported energy	MJ	0.00E+00

Table 13. Supplementary indicators for 1000 kg average PPC cement

Parameters	Unit	Module A1-A3
Non-hazardous waste	kg	6.08E-02
Hazardous waste	kg	9.11E-04
Radioactive waste	kg	2.32E-03

4.8 Interpretation

Table 14. Interpretation of life cycle parameters for 1000 kg average cement

Parameter	Interpretation
ADP elements	Abiotic depletion potential (ADP element) is 7.83E-04 kg Sb-Equiv. of which 99.4% contribution is from grinding process. Clinker production contributes 0.585% total ADP element. Packaging of cement contributes 0.008% of ADP elements. Raw meal preparation and mining process contributes 0.00420% and 0.00503%, respectively. Considering the impacts from grinding process as 100%, gypsum is the most contributing materials for ADP-element with around 99.9%. Considering clinker production as 100%, 87.4% impacts are coming from carbon black emissions and 10.6% from petcoke.
ADP Fossil	Abiotic depletion potential (ADP Fossil) is 3.81E+03 MJ of which 62.7% is contributed by clinker production. The process of cement grinding contributes 32.1% of ADP fossil. Packaging gives 3.54% of ADP-fossil. Considering clinker production impacts as 100%, hard coal emissions contribute 78% and CPP contributes 18.8%. Considering impacts from grinding process as 100%, 80.5% comes from electricity consumption in grinding.
Acidification Potential	Acidification Potential is 2.29E+00 kg SO_2-Equiv. The contribution of clinker production is 52.7%. Grinding of cement contributes 38.1%, raw material production gives 2.19% of acidification potential, while raw meal contributes 2.45% and packaging contributes 2.98%. Considering clinker production impacts as 100%, electricity consumption from CPP in clinker contributes 45.1%. Considering the impacts from grinding process as 100%, electricity consumption from CPP contributes 94.2%.
Eutrophication Potential	Eutrophication Potential is 2.39E-01 kg Phosphate-Equiv. The contribution of clinker production is highest with 81.9% and cement grinding process contributes 14.7%. Considering clinker production impacts as 100%, 84.4% impacts are coming from various air emissions of kiln. Considering the impacts from grinding process as 100%, electricity from CPP contributes 31.9% and the transportation of fuels/materials for grinding contributes 55.2%.
Global Warming Potential	Global Warming Potential is 7.60E+02 kg CO_2-Equiv. The contribution of clinker production is 83.6%, cement grinding process contributes 14.5%. Considering clinker production impacts as 100%, limestone emission contributes highest with 58%, coal emission contributes 29.7% and electricity consumption contributes 6.35%. Considering cement grinding process impacts as 100%, maximum contribution is done by the coal emissions from CPP electricity with 62.8%.
Ozone Depletion Potential	Ozone Layer Depletion Potential is 5.38E-10 kg CFC11-Equiv. The contribution of clinker production process is highest with 88.9%, grinding contributes 9.08%. Considering the cement grinding process impacts as 100%, 48.5% is contributed by concrete admixtures and gypsum contributes 36.5%. Considering clinker production impacts as 100%, 91.9% is contributed by carbon black emissions.

Primary Energy Demand	Primary Energy Demand is 3.86E+03 MJ. The contribution of clinker production is 62.5%, cement grinding process contributes 32.2%, packaging contributes 3.79%, mining and raw meal preparation contributes 1.01% and 0.216% respectively. Considering clinker production impacts as 100%, coal combustion contributes 78.0% while 18.8% is from captive power plant. Considering cement grinding process impacts as 100%, captive power plant contributes 72.6% primary energy demand.
Photochemical Ozone Creation Potential	Photochemical Ozone Creation Potential is 1.19E-01 kg Ethene-Equiv. The major contribution of POCP comes from clinker production i.e. 64.1%, cement grinding process contributes 27.2%, mining process gives 1.99% and packaging process contributes 3.13%. Considering clinker production POCP impacts as 100%, petcoke and carbon back contributes 12.8% and 9.11% respectively, and CPP contributes 30.9%
Water Demand	The net fresh water used is 2.22E-01m^3. The fresh water is mostly used in clinker production with 48.8%, 43.6% in grinding process and 3% in raw meal preparation and packaging each.

5. 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.

6. References

- EN 15804:2012, Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products
- EVS-EN 16908:2017, Cement and building lime- Environmental product declarations- Product category rules complementary to EN 15804. (Estonian Centre for Standardization)
- GABI 8: 2017. thinkstep AG; GaBi 8: Software-System and Database for Life Cycle Engineering. Copyright. Leinfelden, Echterdingen, 1992-2017.
- IS 1489 part 1-Portland Pozzolana Cement-Specification (4rd Revision), Bureau of Indian Standards, December 2015.
- IS 16415- Composite Cement - Specification, Bureau of Indian Standards, December 2015.
- ISO 14020:2001 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.
- PCR for Construction Products and CPC 54 Construction Services/ Prepared by IVL Swedish Environmental Research Institute, Swedish Environmental Protection Agency, SP Trä, Swedish Wood Preservation Institute, Swedisol, SCDA, Svenskt Limträ AB, SSAB, The International EPD System, 2012:01 Version 2.2, Date 2017-05-30.

7. Annexure

7.1 LCIA of Rabriyawas Cement Plants

7.1.1 Ambuja Cement – Dadri

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	1.11E-03
Abiotic Depletion (ADP Fossil)	MJ	3.61E+03
Acidification Potential	kg SO2-Eq.	2.85E+00
Eutrophication Potential	kg Phosphate-Eq.	3.10E-01
Global Warming Potential (GWP 100 years)	kg CO_2-Eq.	7.23E+02
Ozone Layer Depletion Potential (ODP, steady state)	kg CFC11-Eq.	1.70E-09
Photochemical Ozone Creation Potential	kg Ethene-Eq.	1.18E-01
Renewable primary energy as energy carrier	MJ	5.37E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	5.37E+01
Non- renewable primary energy as energy carrier	MJ	3.64E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.64E+03
Use of secondary material	kg	3.40E+02
Use of renewable secondary fuels	MJ	5.68E+01
Use of non- renewable secondary fuels	MJ	2.34E+02
Use of net fresh water	m^3	4.19E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	9.26E-02
Hazardous waste	kg	8.64E-04
Radioactive waste	Kg	7.00E-03

7.1.2 Ambuja Cement - Rabriyawas

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	1.52E-03
Abiotic Depletion (ADP Fossil)	MJ	3.66E+03
Acidification Potential	kg SO2-Eq.	3.90E+00
Eutrophication Potential	kg Phosphate-Eq.	2.95E-01
Global Warming Potential, excl. biogenic carbon	kg CO_2-Eq.	6.92E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	1.64E-09
Photochemical Ozone Creation Potential	kg Ethene-Eq.	2.00E-01
Renewable primary energy as energy carrier	MJ	3.83E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.83E+01
Non- renewable primary energy as energy carrier	MJ	3.69E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.69E+03
Use of secondary material	kg	3.39E+02
Use of renewable secondary fuels	MJ	5.68E+01
Use of non- renewable secondary fuels	MJ	2.34E+02
Use of net fresh water	m^3	3.65E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	1.01E-01
Hazardous waste	kg	4.45E-04
Radioactive waste	kg	7.00E-03

7.2 LCIA of cement products for Maratha Cement Works (MCW)

7.2.1 Ambuja Cement - Maratha Cement Works (MCW)

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	3.93E-04
Abiotic Depletion (ADP Fossil)	MJ	5.36E+03
Acidification Potential	kg SO2-Eq.	3.17E+00
Eutrophication Potential	kg Phosphate-Eq.	2.17E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	8.62E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	3.63E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	1.99E-01
Renewable primary energy as energy carrier	MJ	2.28E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	2.28E+01
Non- renewable primary energy as energy carrier	MJ	5.38E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	5.38E+03
Use of secondary material	kg	3.38E+02
Use of renewable secondary fuels	MJ	7.18E+01
Use of non- renewable secondary fuels	MJ	5.11E+01
Use of net fresh water	m^3	1.53E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	5.48E-02
Hazardous waste	kg	8.11E-04
Radioactive waste	kg	2.00E-03

7.3 LCIA of cement products for Darlaghat

7.3.1 Ambuja Cement - Darlaghat

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	1.39E-03
Abiotic Depletion (ADP Fossil)	MJ	3.10E+03
Acidification Potential	kg SO2-Eq.	1.19E+00
Eutrophication Potential	kg Phosphate-Eq.	1.99E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	6.55E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	2.83E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	9.10E-02
Renewable primary energy as energy carrier	MJ	2.35E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	2.35E+01
Non- renewable primary energy as energy carrier	MJ	3.11E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.11E+03
Use of secondary material	kg	3.44E+02
Use of renewable secondary fuels	MJ	3.22E+00
Use of non- renewable secondary fuels	MJ	7.19E+02
Use of net fresh water	m^3	1.39E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	5.41E-02
Hazardous waste	kg	5.17E-04
Radioactive waste	kg	1.00E-03

7.3.2 Ambuja Cement - Roorkee

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	1.12E-03
Abiotic Depletion (ADP Fossil)	MJ	2.79E+03
Acidification Potential	kg SO2-Eq.	1.58E+00
Eutrophication Potential	kg Phosphate-Eq.	2.31E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	6.90E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	3.25E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	8.30E-02
Renewable primary energy as energy carrier	MJ	4.84E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	4.84E+01
Non- renewable primary energy as energy carrier	MJ	2.80E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	2.80E+03
Use of secondary material	kg	3.45E+02
Use of renewable secondary fuels	MJ	3.22E+00
Use of non- renewable secondary fuels	MJ	7.19E+02
Use of net fresh water	m^3	2.68E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	4.71E-02
Hazardous waste	kg	1.24E-03
Radioactive waste	kg	2.00E-03

7.3.3 Ambuja Cement - Nalagarh

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	1.16E-03
Abiotic Depletion (ADP Fossil)	MJ	2.66E+03
Acidification Potential	kg SO2-Eq.	1.49E+00
Eutrophication Potential	kg Phosphate-Eq.	2.19E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	6.71E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	2.54E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	8.90E-02
Renewable primary energy as energy carrier	MJ	4.46E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	4.46E+01
Non- renewable primary energy as energy carrier	MJ	2.67E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	2.67E+03
Use of secondary material	kg	3.55E+02
Use of renewable secondary fuels	MJ	3.22E+00
Use of non- renewable secondary fuels	MJ	7.19E+02
Use of net fresh water	m^3	2.48E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	4.51E-02
Hazardous waste	kg	5.46E-04
Radioactive waste	kg	1.00E-03

7.3.4 Ambuja Cement - Dadri

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	1.10E-03
Abiotic Depletion (ADP Fossil)	MJ	3.13E+03
Acidification Potential	kg SO2-Eq.	1.61E+00
Eutrophication Potential	kg Phosphate-Eq.	2.50E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	7.02E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	3.01E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	4.10E-02
Renewable primary energy as energy carrier	MJ	4.39E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	4.39E+01
Non- renewable primary energy as energy carrier	MJ	3.14E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.14E+03
Use of secondary material	kg	3.60E+02
Use of renewable secondary fuels	MJ	3.22E+00
Use of non- renewable secondary fuels	MJ	7.19E+02
Use of net fresh water	m^3	2.44E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	4.69E-02
Hazardous waste	kg	8.18E-04
Radioactive waste	kg	1.00E-03

7.3.5 Ambuja Cement - Ropar

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	3.07E-04
Abiotic Depletion (ADP Fossil)	MJ	3.19E+03
Acidification Potential	kg SO2-Eq.	1.45E+00
Eutrophication Potential	kg Phosphate-Eq.	2.22E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	6.89E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	2.60E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	8.40E-02
Renewable primary energy as energy carrier	MJ	1.65E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	1.65E+01
Non- renewable primary energy as energy carrier	MJ	3.20E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.20E+03
Use of secondary material	kg	3.55E+02
Use of renewable secondary fuels	MJ	3.22E+00
Use of non- renewable secondary fuels	MJ	7.19E+02
Use of net fresh water	m^3	2.06E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	5.79E-02
Hazardous waste	kg	5.63E-04
Radioactive waste	kg	1.00E-03

7.3.6 Ambuja Cement - Bhatinda

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	9.81E-04
Abiotic Depletion (ADP Fossil)	MJ	2.77E+03
Acidification Potential	kg SO2-Eq.	1.59E+00
Eutrophication Potential	kg Phosphate-Eq.	2.31E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	6.90E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	3.35E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	8.40E-02
Renewable primary energy as energy carrier	MJ	4.92E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	4.92E+01
Non- renewable primary energy as energy carrier	MJ	2.79E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	2.79E+03
Use of secondary material	kg	3.58E+02
Use of renewable secondary fuels	MJ	3.22E+00
Use of non- renewable secondary fuels	MJ	7.19E+02
Use of net fresh water	m^3	2.67E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	4.95E-02
Hazardous waste	kg	7.13E-04
Radioactive waste	kg	2.00E-03

7.4 LCIA of cement products for Ambuja Nagar

7.4.1 Ambuja Cement – Ambuja Nagar

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	8.52E-04
Abiotic Depletion (ADP Fossil)	MJ	3.61E+03
Acidification Potential	kg SO2-Eq.	1.31E+00
Eutrophication Potential	kg Phosphate-Eq.	2.44E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	8.07E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	2.55E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	9.90E-02
Renewable primary energy as energy carrier	MJ	2.05E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	2.05E+01
Non- renewable primary energy as energy carrier	MJ	3.63E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.63E+03
Use of secondary material	kg	3.08E+02
Use of renewable secondary fuels	MJ	1.30E+01
Use of non- renewable secondary fuels	MJ	2.20E+02
Use of net fresh water	m^3	1.22E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	6.11E-02
Hazardous waste	kg	4.06E-04
Radioactive waste	kg	1.00E-03

7.4.2 Ambuja Cement – Surat

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	2.56E-04
Abiotic Depletion (ADP Fossil)	MJ	3.07E+03
Acidification Potential	kg SO2-Eq.	1.44E+00
Eutrophication Potential	kg Phosphate-Eq.	2.66E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	7.95E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	2.65E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	7.60E-02
Renewable primary energy as energy carrier	MJ	7.95E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	7.95E+01
Non- renewable primary energy as energy carrier	MJ	3.09E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.09E+03
Use of secondary material	kg	3.12E+02
Use of renewable secondary fuels	MJ	9.09E+00
Use of non- renewable secondary fuels	MJ	1.54E+02
Use of net fresh water	m^3	1.28E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	4.67E-02
Hazardous waste	kg	1.09E-03
Radioactive waste	kg	1.00E-03

7.5 LCIA of cement products for Bhatapara

7.5.1 Ambuja Cement – Sankrail

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	2.82E-04
Abiotic Depletion (ADP Fossil)	MJ	4.31E+03
Acidification Potential	kg SO2-Eq.	2.83E+00
Eutrophication Potential	kg Phosphate-Eq.	2.21E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	8.07E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	4.78E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	9.40E-02
Renewable primary energy as energy carrier	MJ	4.45E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	4.45E+01
Non- renewable primary energy as energy carrier	MJ	4.33E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	4.33E+03
Use of secondary material	kg	3.68E+02
Use of renewable secondary fuels	MJ	5.26E+00
Use of non- renewable secondary fuels	MJ	1.09E+02
Use of net fresh water	m^3	2.45E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	0.00E+00
Hazardous waste	kg	0.00E+00
Radioactive waste	kg	2.00E-03

7.5.2 Ambuja Cement – Farakka

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	8.18E-04
Abiotic Depletion (ADP Fossil)	MJ	4.06E+03
Acidification Potential	kg SO2-Eq.	2.72E+00
Eutrophication Potential	kg Phosphate-Eq.	2.12E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	7.58E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	5.20E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	8.60E-02
Renewable primary energy as energy carrier	MJ	5.27E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	5.27E+01
Non- renewable primary energy as energy carrier	MJ	4.07E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	4.07E+03
Use of secondary material	kg	3.61E+02
Use of renewable secondary fuels	MJ	5.26E+00
Use of non- renewable secondary fuels	MJ	1.09E+02
Use of net fresh water	m^3	2.94E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	5.95E-02
Hazardous waste	kg	1.79E-03
Radioactive waste	kg	2.00E-03

7.5.3 Ambuja Cement – Bhatapara: Compocem

LCIA Impact Category	Unit	Module A1- A3
Abiotic Depletion (ADP elements)	kg Sb-Eq.	6.05E-04
Abiotic Depletion (ADP Fossil)	MJ	3.77E+03
Acidification Potential	kg SO2-Eq.	4.50E+00
Eutrophication Potential	kg Phosphate-Eq.	1.69E-01
Global Warming Potential, excl biogenic carbon	kg CO_2-Eq.	5.95E+02
Ozone Layer Depletion Potential	kg CFC11-Eq.	2.37E-10
Photochemical Ozone Creation Potential	kg Ethene-Eq.	2.22E-01
Renewable primary energy as energy carrier	MJ	3.11E+01
Renewable primary energy resources as raw materials	MJ	0.00E+00
Total renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.11E+01
Non- renewable primary energy as energy carrier	MJ	3.96E+03
Non- renewable primary energy resources as raw materials	MJ	0.00E+00
Total non- renewable primary energy resources (primary energy and primary energy resources as raw materials)	MJ	3.96E+03
Use of secondary material	kg	
Use of renewable secondary fuels	MJ	5.66E-01
Use of non- renewable secondary fuels	MJ	5.56E+01
Use of net fresh water	m^3	1.45E-01
Components for reuse	kg	0.00E+00
Materials for recycling	Kg	0.00E+00
Exported energy	MJ	0.00E+00
Materials for energy recovery	Kg	0.00E+00
Non-hazardous waste	kg	4.61E-02
Hazardous waste	kg	8.10E+05
Radioactive waste	kg	1.00E-03