LCA REPORT

Precast concrete products

ISO14025, ISO14044, EN15804
Date of report: 2021-09-29

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Precast concrete products

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1 Introduction

The study is conducted by consultants from WSP and is commissioned by Bohus Betong. The purpose of the study is to develop four EPDs and this report serves as a basis for verification of the EPDs in accordance with EN 15804:2012 + A1. The study has been conducted according to the requirements of ISO 14044:2006, EN 15804:2012, ISO 14025:2006 and PCR 2012:01, Construction products and construction services, (EN 15804:A1) v.2.33.

Bohus Betong AB is an independent privately-owned company established in 1925. The company's business idea is to "design, manufacture, deliver and assemble complete concrete structures for housing, agricultural buildings, and offices". Bohus Betong has about 60 employees motivated to make high quality products to their customers every day.

Products from Bohus Betong AB is certified by Nordcert according to EN 305 and other standards. The certification is a security that all products fulfil all their technical requirements and that they are manufactured according to current building norms.

1.1 Product information

The report covers four different products, and an EPD has been developed for each of the products.

1.1.1 *Solid precast concrete balcony, access balcony, beams and columns*

Balconies and access balconies are normally used in block buildings and beams/columns are used more or less in all kinds of buildings. Columns and beams are often a main part of the load bearing structure in a building. Columns are produced with circular, square, or rectangular cross section. Beams are normally produced in rectangular or T cross sections. Balconies can be fixed to the slab by different fixing systems or placed on columns.

1.1.2 *Solid precast concrete walls*

Solid walls are used in different varieties and often as a part of a structure in a building. The wall is solid concrete in one layer but, depending on the customer's needs, the thickness and other technical specifications can vary. Each element is customised for an individual project and are produced according to a requirements specification from the customer. This can include recesses and other details such as electrical wires.

1.1.3 *Insulated precast concrete sandwich walls*

Sandwich walls are normally used as facades and sometimes as isolated walls between areas with different temperatures. The wall has two layers of concrete with insulation in between. Depending on the customer's needs, the type of insulation and the thickness can vary. Bohus Betong offer different decorative surfaces on the facade according to customer's needs. Each element is customised for individual projects.

1.1.4 *Solid precast concrete, pre-stressed, slab elements*

Solid slab elements are used in different varieties and reinforced with steel bars and prestressed steel wires. Each element is customised for an individual project and the elements are produced according to a requirements specification from the customer. This can include recesses and other details for electrical wires, drains and ventilation pipes.

2 Goal and scope

2.1 Goal of the study

The goal of the study has been to provide necessary data and documentation to produce four EPDs according to the requirements of PCR2012-01 v2.33 Construction products and construction services, and to gain insight into the environmental impacts related to precast concrete products used in various buildings on the Swedish market.

Results from the LCA study will be published in an environmental product declaration type III (EPD) for the products.

This LCA report will *not* be open to the public. It is up to Bohus Betong to decide whether they want to use it in discussions with B2B clients or not.

2.2 Declared unit

2.2.1 *Declared unit*

The study is conducted on a declared unit rather than a functional unit, as the system boundaries are confined to Cradle-to-gate with options, rather than cradle-to-grave.

The declared unit is: 1 metric tonne (1000 kg) of precast concrete product of the following products:

- Solid precast concrete balcony, access balcony, beams and columns.
- Solid precast concrete wall.
- Insulated precast concrete sandwich wall.
- Solid precast concrete, pre-stressed, slab elements.

2.2.2 *Calculation rules for averaging data*

The precast concrete products are manufactured at Bohus Betong's production sites in Dingle and Jönköping. The production site that produces the majority of the product group has been assumed to produce 100% of the products in that group. The manufacturing processes and raw materials used in both sites corresponds to each other, therefore it can be assumed that the environmental impact they create are of the same kind. For each product group, this entails the following, see Table 1.

Table 1. Assumptions for production locations.

Product	Produced in Dingle	Produced in Jönköping	Assumption
Solid precast concrete balcony, access balcony, beams and columns	90 %	10 %	100 % produced in Dingle
Solid precast concrete wall	100 %	-	None
Insulated precast concrete sandwich wall	100 %	-	None
Solid precast concrete, pre-stressed, slab elements	14 %	86 %	100 % produced in Jönköping

Heat, electricity and other energy use as well as waste in production are calculated as a weighted averages per produced tonne of all products using total yearly production data and rate respectively for both sites during 2020.

2.3 System boundaries

2.3.1 *System boundaries*

The study starts with the extraction of the natural resources, covers transport from suppliers to the manufacturing site, production at Bohus Betong and transport to the end-user, see Figure 1. No secondary materials or recovered energy is used in the production. No assumptions made.

The use-phase of the products, B1, is included in the study to cover the absorption of carbon dioxide by concrete, see more details in section 3.2.5 *Module B1*. The concrete continuously absorbs carbon dioxide during the use-phase as well as in the end-of-life phase. It is the net-emissions from the cradle-to-gate activities and the absorption of carbon dioxide which has a real impact on climate warming. By including the uptake of carbon dioxide in this EPD, the cradle-to-gate with options study provides a more coherent picture of the climate impact from the product. Only the carbonation in the use-phase is considered in this study, to get a full picture of the climate impact also the end-of-life phase needs to be included.

	Product stage			Construction process stage		Use stage							End of life stage				Resource recovery stage
	Raw material supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
Module	**A1**	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
Modules declared	x	x	x	x	ND	x	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Geography	EU	EU	SE	SE	-	SE	-	-	-	-	-	-	-	-	-	-	-
Specific data used	20-40 % depending on the product					-	-	-	-	-	-	-	-	-	-	-	-
Variation – products	within +/- 10 % compared to the given average in each EPD					-	-	-	-	-	-	-	-	-	-	-	-
Variation – sites	<10 %					-	-	-	-	-	-	-	-	-	-	-	-

Figure 1: Life cycle stages covered and modules for the assessment (X= Module assessed, ND= Not declared).

2.3.2 *Technical flowchart*

In figure 2, the materials and activities included in A1-A4 and B1 are presented.

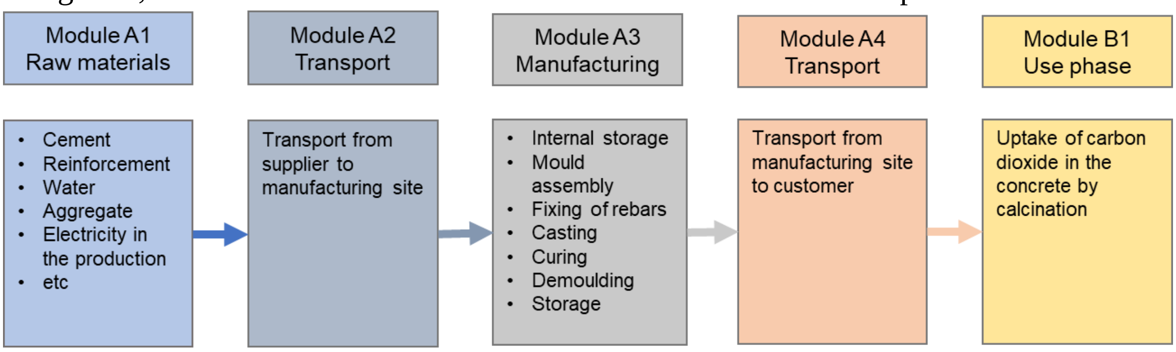

Figure 2. Technical flowchart for Bohus Betong.

2.3.3 *Cut-off criteria for initial inclusion of inputs and outputs*

All major materials, production energy use and waste created are included in the study. The materials below, which weight less than 1 % of the products total weight, are not taken into account.

- Concrete admixtures
  - Superplasticizer masterglenium Ace 435 produced by Masters builders solution.
  - Air-entraining admixtures Masterair 100, produced by Masters builders solution
  - Dynamon SX-A170, produced by Mapei.

    - Superplasticizers dynamon SR-N
- Ingots: iron hooks to facilitate lifting, plastic cable channels for electric wires or plastic plumbing pipes.

There are no SVHC substances according to REACH in the additives according to declaration from the manufacturer of additives.

2.4 Geographical system boundaries

The EPDs covered by this report are valid for precast concrete products manufactured in Sweden at the site in Jönköping and Dingle.

2.5 Temporal system boundaries

The reference year for calculations is 2020 and production data have been collected by representatives at the production sites. The quality of these data can be deemed as good.

Assessment period for background data taken from Ecoinvent 3.6 is 2010-2019, and 2014 for Agri-footprint.

2.6 Technology coverage

European mean values/technology mixes have been taken from "Ecoinvent 3.6 *cut off by characterization"* to represent the environmental impact from supplied materials. The materials are supplied from suppliers in Europe. For some materials, EPD data have been used. Generic LCA data for lorry transports from "Agri-footprint – mass allocation" has been used for transport from suppliers to Bohus Betong's production site as well as the transport from the production site to the customer.

The software SimaPro Analyst 9.1.1.1 has been used for all calculations of environmental impact figures. The methods CML-IA, EDIP 2003, Cumulative energy demand and AWARE have been used to retrieve the characterization results.

The concrete carbonatization calculation in B1 has been done according to the standard SS-EN 16757:2017 – Sustainability of construction works – Environmental product declarations – Product Category Rules for concrete and concrete elements.

3 Life cycle inventory analysis

3.1 Data collection procedures

Representatives at Bohus Betong have delivered specific data for ingredients in products, process related energy and electricity use, waste and transports, etc. For some materials, EPD-data were used. The remainder of the data was collected from database Ecoinvent 3.6 and Agri-footprint with extra care to find representative datasets.

3.2 Quantitative and qualitative descriptions of unit processes

3.2.1 *Module A1*

Materials in the different concrete products are shown in the Table 2. This information has been obtained from Bohus Betong's representatives.

Module A1 includes raw material supply:

- Extraction and processing of raw materials (e.g., mining processes and crude oil extraction) but not including those processes that are part of the waste processing in the previous product system.
- Generation of electricity, steam and heat from primary energy resources, also including their extraction, refining and transport. This also includes energy needed for raw material supply and energy for manufacturing in core process.
- Extraction and processing up to the end-of-waste state or disposal of final residues (waste) including any packaging not leaving the factory gate with the product.

There are variations in the mix of materials (cement, reinforcement, gravel etc.) in the different concrete products, see Table 2. Material percentages in the table are averages for respective product. However, a sensitivity study has shown that the variation in material composition for different recipes and the related environmental impact is within +/- 10 % compared to the given average.

There are no SVHC substances according to REACH in the product or in the waste.

Table 2. Weight percentages for materials in each product.

Weight % per tonne product	Reinforcement	Cement	Aggregate	Water	EPS insulation	Concrete
Solid precast concrete balcony, access balcony, beams and columns	2.8	18.8	70.6	7.8	-	-
Solid precast concrete wall	2.9	14.8	74.2	8.1	-	-
Solid precast concrete, pre-stressed, slab element	0.6	-	-	-	-	99.4
Insulated precast concrete sandwich walls	3.5	14.6	73.2	8.1	0.6	-

The reinforcement makes up of three different components: reinforcement net, reinforcement bars and prestressed steel for reinforcement of concrete (PC-strand). The share of each component per product is shown in Table 3. For solid concrete, pre-stressed, slab elements 100 % of PC-strand is assumed in the calculations.

Table 3. Share of reinforcement type in each product.

Weight % per tonne product	Unit	Reinforcement net	Reinforcement bars	PC-strand	Total
Solid precast concrete balcony, access balcony, beams and columns	%	24 %	76 %	-	100 %
	kg/tonne product	7	21	-	28
Solid precast concrete wall	%	90 %	10 %	-	100 %
	kg/tonne product	26	3	-	29
Solid precast concrete, pre-stressed, slab element	%	-	12 %	88 %	100 %
	kg/tonne product	-	0.7	5.3	6
Insulated precast concrete sandwich walls	%	50 %	50 %	-	100 %
	kg/tonne product	17.5	17.5	-	35

At the manufacturing site in Dingle, concrete is produced by putting aggregate, cement, water and admixtures in a concrete mixer. The mixture is poured into moulds and reinforcement is added. After one night in the moulds, the concrete has hardened, and the mould is removed. At the production site in Jönköping, the process is similar, with the main difference that the concrete is bought ready-made and put directly into the moulds. The impact from the concrete in Jönköping has been calculated from an EPD made by the manufacturer specifically for the concrete delivered to Jönköping manufacturing site.

Heat, electricity and other energy use as well as waste in production are calculated as an average per produced tonne of all products using total yearly production data and rate for the respective sites during 2020. At the manufacturing site in Dingle, *14.21 kWh electricity* and *2.45 kg Pellets* per tonne product is used. In Jönköping, *2.96 kWh electricity* per tonne product is used. Waste produced in both locations are metal, wood, plastic, paper and writing paper.

3.2.2 *Module A2*

Module A2 includes external transportation to the core processes and internal transports.

Bohus Betong’s representatives have gathered information about transports from suppliers to the manufacturing site in Dingle and Jönköping. Table 4 and 5 show the average distance the raw materials have been transported. The total transport distance for each raw material has been calculated by weighting the percentage of materials arrived from each supplier and the distance they represent.

LCA calculations have been made combining distance information with generic LCI data for lorry and ship transport. The lorries used are a mix of Euro 5 and 6 standards depending on the material, some materials are transported with both types. The majority of lorries have a weight over 20 tonnes.

Table 4. Average transport distances for raw materials to Dingle.

Raw material		Suppliers	Share	Distance to Dingle
Reinforcement	Reinforcement net	Net A	90 %	1 068 km truck
		Net B	10 %	706 km truck 405 km ship
	PC-strand		100 %	354 km truck
	Reinforcement bar	Bar A	80 %	610 km truck 275 km ship
		Bar B	20 %	706 km truck 405 km ship
Cement			100 %	165.5 km truck
Aggregate			100 %	35.2 km truck
EPS Insulation			100 %	108 km truck

Table 5. Average transport distances for raw materials to Jönköping.

Raw material	Distance to Jönköping
PC-strand	129 km truck

3.2.3 *Module A3*

Module A3 includes:

- Manufacturing of the construction product
- Production of ancillary materials or pre-products
- Treatment of waste generated from the manufacturing processes

Dingle production facility uses pellets to heat the production site. The site uses *2.45 kg* pellets per tonne product produced in Dingle. The combustion of the pellets is included in A3 and the refinement and production of the pellets is included in A1. Jönköping uses no other energy source than electricity, which is included in A1.

3.2.4 *Module A4*

Module A4 includes the transport to customers from respective production site. The distances are shown in Table 6. The distances are averages calculated by representatives at Bohus Betong. LCA calculations have been made combining distance information with generic LCI data for lorry transport. The lorries used are of Euro 6 standard.

Table 6. Distance to customer from production sites.

Distance to customer from Bohus Betong	Distance
Dingle	102 km truck
Jönköping	102 km truck

3.2.5 *Module B1*

In Module B1, the use-phase of the precast concrete products is included. However, only the carbonation process of concrete is considered in the use-phase. The precast concrete products are used in various buildings and the carbonation process is considered to cover the main part of the activities during the use-phase.

Carbonation of concrete is a chemical reaction where CO_2 in air penetrated the concrete and reacts with hydration products in the concrete. The CO_2 uptake in this module depends on the concrete strength and the exposure conditions. The calculation procedure and the data used is presented in section *3.5.3 Calculation of module B1*. The data needed have been collected by Bohus Betong's representatives.

3.3 Sources of data used to conduct LCA

In Table 7, data sources used are presented.

Table 7: List of data sources for precast products.

<table>
<tr><th>Submodule</th><th>Material/ energy flow</th><th>Data description</th><th>Source</th><th>Data quality (specific/ generic)</th></tr>
<tr><td rowspan="16">A1</td><td>Reinforcement</td><td>Reinforcement net and bar</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td>Reinforcement</td><td>PC- strand</td><td>EPD, registration number: S-P-00810</td><td>Specific</td></tr>
<tr><td>Cement</td><td>CEM I 52.5 R bulk Portland cement</td><td>EPD-HCG-20190140-CAA1-EN</td><td>Specific</td></tr>
<tr><td>Aggregate</td><td>Gravel, crushed</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td>Water</td><td>Water</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td>Insulation</td><td>Lavlambda EPS 80 isolasjon (trykklasse 80)</td><td>NEPD-1236-244-NO</td><td>Specific</td></tr>
<tr><td>Concrete</td><td>EPD developed specifically to this study by the producers.</td><td>EPD</td><td>Specific</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Waste</td><td>Metal</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td>Wood</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td>Plastic</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td>Paper</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td>Writing paper</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Energy extraction</td><td>Pellets</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td>Electricity</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">A2</td><td rowspan="3">Transport from supplier to manufacturing</td><td>Lorry transport</td><td>Agri-footprint – mass allocation</td><td>Generic</td></tr>
<tr><td>Ship transport</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td>Internal diesel truck</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>A3</td><td>Process energy</td><td>Pellets</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>A4</td><td>Transport from Bohus Betong to customer</td><td>Lorry transport</td><td>Ecoinvent v3.6</td><td>Generic</td></tr>
</table>

3.4 Validation of data

3.4.1 *Data quality assessment*

Specific data for product composition and transport distances from supplier to manufacturing units are used. Energy data from manufacturing are also based on specific yearly production data (2020) collected by Bohus Betong's representatives.

LCI data for calculating environmental impact for other materials and energy use is taken from the Ecoinvent 3.6 database, http://www.ecoinvent.org/. LCI data for transports are taken from the Agri-footprint database, https://www.agri-footprint.com/. Impact for some materials is taken from material specific EPD documents, see Table 7 above. For details about selected generic datasets see Table 8.

Table 8. List of data sources for generic data.

<table>
<tr><th>Material/ energy flow</th><th>Data description</th><th>Source</th></tr>
<tr><td>Reinforcement</td><td>Reinforcement net and bar</td><td>Reinforcing steel {GLO}| market for | Cut-off, S</td></tr>
<tr><td>Aggregate</td><td>Gravel, crushed</td><td>Gravel, crushed {CH}| market for gravel, crushed | Cut-off, S</td></tr>
<tr><td>Water</td><td>Water</td><td>Water, deionized, from tap water, at user {Europe without Switzerland} | market for water, deionized, from tap water, at user | Cut-off, S</td></tr>
<tr><td rowspan="5">Waste</td><td>Metal</td><td>Reinforcing steel {RER}| production | Cut-off, S</td></tr>
<tr><td>Wood</td><td>Oriented strand board {RER}| production | Cut-off, S</td></tr>
<tr><td>Plastic</td><td>Polyethylene terephthalate, granulate, amorphous {RER}| production | Cut-off, S</td></tr>
<tr><td>Paper</td><td>Corrugated board box {RER}| production | Cut-off, S</td></tr>
<tr><td>Writing paper</td><td>Paper, woodfree, uncoated {RER}| market for | Cut-off, S</td></tr>
<tr><td rowspan="2">Energy extraction</td><td>Pellets</td><td>Wood pellet, measured as dry mass {RER}| market for wood pellet | Cut-off, S</td></tr>
<tr><td>Electricity</td><td>Electricity, medium voltage {SE}| market for | Cut-off, S</td></tr>
<tr><td rowspan="2">Transport from supplier to manufacturing</td><td>Lorry transport</td><td>Transport, truck >20t, EURO 5, 80%LF, empty return/Glo mass</td></tr>
<tr><td>Internal diesel truck</td><td>Diesel, burned in transport machinery {GLO}| market for diesel, burned in agricultural machinery | Cut-off, S</td></tr>
<tr><td>Process energy</td><td>Pellets</td><td>Heat, district or industrial, other than natural gas {RoW}| heat production, softwood chips from forest, at furnace 5000kW | Cut-off, S</td></tr>
<tr><td>Transport from Bohus Betong to customer</td><td>Lorry transport</td><td>Transport, truck >20t, EURO 5, 80%LF, empty return/Glo mass</td></tr>
</table>

3.4.2 *Data selection*

The data selected for the transportation by lorry is an averaging of the different transport modes the materials and the final transport is carried out by. The dataset also includes empty returns and a load factor of 80 %. This dataset as a whole is considered to be a conservative choice for the environmental impact for the transport.

Bohus Betong uses different insulation products depending on customer selection, these are: Expanded polystyrene (EPS) foam insulation delivered from Jackon in Norway and Hardrock Elementbatts from Rockwool. Both products have registered EPDs. The EPDs show that the

EPS insulation has a higher environmental load compared to Rockwool. As a conservative measure, the environmental impact values for EPS (NEPD-1236-244-NO) has been used in the EPD calculations for the insulated precast products.

3.5 Allocation principles and procedures

3.5.1 *Documentation and justification of allocation procedures*

The allocation is made in accordance with provisions in EN-15804. Incoming energy and waste are allocated equally among all products through mass allocation.

3.5.2 *Calculation procedure in SimaPro*

Emission factors for materials, energy and transports etc. according to Table 8 have been selected in SimaPro. The factors have been combined with related mass of materials and amount of energy as well as transport distances in modules covering A1 – A4 for precast concrete products.

See screen-print from SimaPro calculation in Figure 3. The picture shows the final calculation setup for an insulated solid precast concrete balcony, access balcony, beams and columns.

Namn	Status	Kommentar
Dingle - Balcony	Icke	ton

Material/hopsättningar	Mängd	Enhet	Fördelning	SD^2 eller 2	Min
A1 Reinforcement	28	p	Odefiniera		
A1 Aggregate	706	p	Odefiniera		
A1 Water	78	p	Odefiniera		
A1 Cement	188	p	Odefiniera		
Dingle - A1 Production energy/tonne prefab	1	p	Odefiniera		
Dingle - A1 Waste per tonne prefab	1	p	Odefiniera		
Dingle A2 - internal transport	1	p	Odefiniera		
A2 Transport 1 kg reinforcement bars	21	p	Odefiniera		
A2 Transport 1 kg reinforcement net	7	p	Odefiniera		
A2 Transport 1 kg aggregate	706	p	Odefiniera		
A2 Transport 1 kg cement	188	p	Odefiniera		
Dingle - A3 Pellets	1	p	Odefiniera		
Dingle A4 - Transport 1 tonne to end-user	1	p	Odefiniera		
(Infoga linje här)					

Processer	Mängd	Enhet	Fördelning	SD^2 eller 2	M
(Infoga linje här)					

Figure 3. Print screen from SimaPro.

3.5.3 *Calculation of module B1*

The CO_2 uptake in a precast concrete product can be calculated according to Equation 1.

Equation 1. The CO_2 uptake in kg per m^2 concrete surface during t years.[1]

$$CO_{2\ uptake} = k * \left(\frac{\sqrt{t}}{1000}\right) * U_{tcc} * C * (D_c)$$

Where the k-factor k [mm/year$^{0.5}$] and D_c is the degree of carbonation [percentage]. k and D_c are factors depending on the *concrete strength* and the *placement of the product* and is collected from Table 9. U_{tcc} is the maximum theoretical uptake in kg CO_2/kg cement, C is cement content in kg/m^3 of concrete and t is the time in years.

[1] SS-EN 16757:2017 – Sustainability of construction works – Environmental product declarations – Product Category Rules for concrete and concrete elements.

Table 9. Table with k and D_c factors. Source: SS-EN 16757:2017 – Sustainability of construction works – Environmental product declarations – Product Category Rules for concrete and concrete elements.

Concrete strength	**< 15 MPa**	**15 to 20 MPa**	**25 to 35 MPa**	**>35 MPa**	**Degree of carbonation (Dc)**
Parameters	Value of k-factor, in mm/year$^{0.5}$				Percentage
Civil engineering structures					
Exposed to rain		2.7	1.6	1.1	85
Sheltered from rain		6.6	4.4	2.7	75
In ground [a]		1.1	0.8	0.5	85
Buildings					
Outdoor					
Exposed to rain	5.5	2.7	1.6	1.1	85
Sheltered from rain	11	6.6	4.4	2.7	75
Indoor in dry climate [c]					
With cover [b]	11.6	6.9	4.6	2.7	40
Without	16.5	9.9	6.6	3.8	40
In ground [a]		1.1	0.8	0.5	85
[a] Under groundwater level k=0.2.					
[b] Paint or wallpaper. (Under tiles, parquet and laminate k is considered to be 0.)					
[c] Indoor in dry climate means that the RH is normally between 45 % and 65 %.					

In Table 10, the values used for the different products are declared and the values are averages.

Table 10. Table with the parameters used for each product in equation 1.

Parameters	Solid precast concrete balcony, access balcony, beams and columns	Solid precast concrete wall	Solid precast concrete, pre-stressed, slab element	Insulated precast concrete sandwich walls
Concrete strength [Mpa]	>35	>35	>35	>35
Placement of products	Two sides - outdoor exposed to rain	Two sides - indoor in dry climate, with cover	One side - indoor in dry climate, with cover	One side - outside exposed to rain.
			One side – covered by parquet, tiles or laminate*	One side - indoor in dry climate, with cover
U_{tcc} [CO_2/kg cement]	0.49	0.49	0.49	0.49
C kg /m^3 of concrete	418	421	520	438
t [years]	50	50	50	50
m^2 one side	2	2	1.5	0.5

** k value is considered to be 0.*

The CO_2 uptake per m^2 is converted to CO_2 uptake per tonne precast concrete product with the known area per tonne precast concrete product. The products have two sides and the CO_2 uptake for each is added together.

4 Life cycle impact assessment

4.1 Characterization models, factors and methods

The environmental impact as indicated in the tables below will be calculated using the SimaPro Analyst 9.1.1.1. program. Calculation methods CML-IA, EDIP 2003, Cumulative energy demand and AWARE have been used to retrieve the characterization results.

Table 11. Parameters describing environmental impacts (EN15804 2012).

Impact Category	Parameter	Unit (expressed per declared unit)
Global Warming	Global warming potential, GWP	kg CO_2- equiv. 100 yr.
Ozone Depletion	Depletion potential of the stratospheric ozone layer, ODP	kg CFC-11- equiv. 20 yr.
Acidification for soil and water	Acidification potential of soil and water, AP	kg SO_2 – equiv.
Eutrophication	Eutrophication potential, EP	kg PO_4 – equiv.
Photochemical ozone creation	Formation potential of tropospheric ozone, POCP	kg C_4H_4- equiv.
The abiotic depletion potential is calculated and declared in two different indicators: • ADP-elements (kg Sb equiv.): include all non-renewable, abiotic material resources (i.e. except fossil resources) • ADP-fossil fuels (MJ net calorific value): include all fossil resources		

Table 12. Parameters describing resource use.

Parameter	Unit (expressed per declared unit)
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ net calorific value
Use of renewable primary energy resources used as raw materials	MJ net calorific value
Total use of renewable primary energy resources (primary energy and primary energy resources used as materials)	MJ net calorific value
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	MJ net calorific value
Use of non-renewable 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 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
Net use of fresh water	m^3

Table 13. Other environmental information describing waste categories.

Parameter	Unit (expressed per declared unit)
Hazardous waste disposed*	kg
Non-hazardous waste disposed	kg
Radioactive waste disposed	kg
Components for re-use	kg
Materials for recycling	kg
Materials for energy recovery	kg
Exported energy	MJ per energy carrier

*The characteristics that render waste hazardous are described in existing applicable legislation, e.g. in the European Waste Framework Directive.

The estimated impact results are only relative statements, which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks.

5 Calculation results

5.1 Calculation results per tonne solid precast balcony, access balcony, beams and columns

Potential environmental impact

Results per tonne solid precast concrete balcony, access balcony, beams and columns							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Global warming potential (GWP)	kg CO_2 eq.	2.25E+02	1.12E+01	3.79E-01	2.36E+02	1.03E-02	-6.09E+00*
Depletion potential of the stratospheric ozone layer, (ODP)	kg CFC-11 eq.	8.19E-06	5.11E-07	3.20E-08	8.73E-06	2.10E-11	0.00E+00
Acidification potential (AP)	kg SO_2 eq.	4.11E-01	6.94E-02	5.35E-03	4.86E-01	4.33E-05	0.00E+00
Eutrophication potential (EP)	kg PO_4^{3-} eq.	2.04E-01	1.47E-02	1.96E-03	2.21E-01	9.90E-06	0.00E+00
Formation potential of tropospheric ozone (POCP)	kg C_2H_4 eq.	5.75E-02	2.83E-03	4.69E-04	6.08E-02	2.12E-06	0.00E+00
Abiotic depletion potential – Elements	kg Sb eq.	8.21E-04	1.43E-04	3.11E-06	9.67E-04	4.14E-10	0.00E+00
Abiotic depletion potential – Fossil resources	MJ, net calorific value	1.10E+03	1.54E+02	4.18E+00	1.26E+03	1.46E-01	0.00E+00

* *Only the carbonation of the product is considered in the use phase as it is strongly related to the calcination in A1 (net CO_2 emission) and the CO_2 uptake is calculated for 50 years.*

Use of resources

Results per tonne solid precast concrete balcony, access balcony, beams and columns								
Indicator		**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Primary energy resources – Renewable	Use as energy carrier	MJ, net calorific value	3.81E+02	3.80E+00	5.90E+01	4.44E+02	1.96E-04	0.00E+00
	Used as raw materials	MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TOTAL	MJ, net calorific value	3.81E+02	3.80E+00	5.90E+01	4.44E+02	1.96E-04	0.00E+00
Primary energy resources – Non-renewable	Use as energy carrier	MJ, net calorific value	1.42E+03	1.65E+02	4.92E+00	1.59E+03	1.56E-01	0.00E+00
	Used as raw materials	MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TOTAL	MJ, net calorific value	1.42E+03	1.65E+02	4.92E+00	1.59E+03	1.56E-01	0.00E+00
Secondary material		kg	3.46E+01	0.00E+00	0.00E+00	3.46E+01	0.00E+00	0.00E+00
Renewable secondary fuels		MJ, net calorific value	5.04E+01	0.00E+00	0.00E+00	5.04E+01	0.00E+00	0.00E+00
Non-renewable secondary fuels		MJ, net calorific value	1.11E+02	0.00E+00	0.00E+00	1.11E+02	0.00E+00	0.00E+00
Net use of fresh water		m^3	6.99E+01	2.51E-01	4.67E-02	7.02E+01	3.99E-05	0.00E+00

Waste production and output flows

Waste production

Results per tonne solid precast concrete balcony, access balcony, beams and columns							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Hazardous waste disposed	kg	4.80E-03	1.33E-04	8.50E-06	4.94E-03	0.00E+00	0.00E+00
Non-hazardous waste disposed	kg	1.83E+01	4.50E-01	1.35E-01	1.89E+01	1.35E-01	0.00E+00
Radioactive waste disposed	kg	3.13E-03	2.76E-04	2.06E-05	3.42E-03	0.00E+00	0.00E+00

Output flows

Results per tonne solid precast concrete balcony, access balcony, beams and columns							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Components for re-use	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Material for recycling	kg	0.00E+00	0.00E+00	3.14E+00	3.14E+00	0.00E+00	0.00E+00
Materials for energy recovery	kg	0.00E+00	0.00E+00	6.04E+00	6.04E+00	0.00E+00	0.00E+00
Exported energy, electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

5.2 Calculation results per tonne solid precast concrete wall

Potential environmental impact

Results per tonne solid precast concrete, wall							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B4**
Global warming potential (GWP)	kg CO_2 eq.	1.94E+02	1.10E+01	3.79E-01	2.05E+02	1.03E-02	-6.33E+00*
Depletion potential of the stratospheric ozone layer, (ODP)	kg CFC-11 eq.	7.69E-06	4.30E-07	3.20E-08	8.15E-06	2.10E-11	0.00E+00
Acidification potential (AP)	kg SO_2 eq.	3.93E-01	5.73E-02	5.35E-03	4.55E-01	4.33E-05	0.00E+00
Eutrophication potential (EP)	kg PO_4^{3-} eq.	1.99E-01	1.35E-02	1.96E-03	2.14E-01	9.90E-06	0.00E+00
Formation potential of tropospheric ozone (POCP)	kg C2H4 eq.	5.56E-02	2.55E-03	4.69E-04	5.86E-02	2.12E-06	0.00E+00
Abiotic depletion potential – Elements	kg Sb eq.	8.40E-04	1.39E-04	3.11E-06	9.83E-04	4.14E-10	0.00E+00
Abiotic depletion potential – Fossil resources	MJ, net calorific value	1.05E+03	1.52E+02	4.18E+00	1.21E+03	1.46E-01	0.00E+00

* *Only the carbonation of the product is considered in the use phase as it is strongly related to the calcination in A1 (net CO_2 emission) and the CO_2 uptake is calculated for 50 years.*

Use of resources

Results per tonne solid precast concrete, wall								
Indicator		**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B4**
Primary energy resources – Renewable	Use as energy carrier	MJ, net calorific value	3.64E+02	3.76E+00	5.90E+01	4.27E+02	1.96E-04	0.00E+00
	Used as raw materials	MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TOTAL	MJ, net calorific value	3.64E+02	3.76E+00	5.90E+01	4.27E+02	1.96E-04	0.00E+00
Primary energy resources – Non-renewable	Use as energy carrier	MJ, net calorific value	1.35E+03	1.63E+02	4.92E+00	1.52E+03	1.56E-01	0.00E+00
	Used as raw materials	MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TOTAL	MJ, net calorific value	1.35E+03	1.63E+02	4.92E+00	1.52E+03	1.56E-01	0.00E+00
Secondary material		kg	3.49E+01	0.00E+00	0.00E+00	3.49E+01	0.00E+00	0.00E+00
Renewable secondary fuels		MJ, net calorific value	3.97E+01	0.00E+00	0.00E+00	3.97E+01	0.00E+00	0.00E+00
Non-renewable secondary fuels		MJ, net calorific value	8.72E+01	0.00E+00	0.00E+00	8.72E+01	0.00E+00	0.00E+00
Net use of fresh water		m^3	7.26E+01	2.43E-01	4.67E-02	7.29E+01	3.99E-05	0.00E+00

Waste production and output flows

Waste production

Results per tonne solid precast concrete, wall							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Hazardous waste disposed	kg	4.95E-03	1.27E-04	8.50E-06	5.09E-03	0.00E+00	0.00E+00
Non-hazardous waste disposed	kg	1.89E+01	4.36E-01	1.35E-01	1.94E+01	1.29E-08	0.00E+00
Radioactive waste disposed	kg	3.18E-03	2.30E-04	2.06E-05	3.43E-03	0.00E+00	0.00E+00

Output flow

Results per tonne solid precast concrete, wall							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Components for re-use	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Material for recycling	kg	0.00E+00	0.00E+00	3.14E+00	3.14E+00	0.00E+00	0.00E+00
Materials for energy recovery	kg	0.00E+00	0.00E+00	6.04E+00	6.04E+00	0.00E+00	0.00E+00
Exported energy, electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

5.3 Calculation results per tonne insulated precast concrete, sandwich wall

Potential environmental impact

Results per tonne insulated precast concrete, sandwich wall							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Global warming potential (GWP)	kg CO_2 eq.	2.10E+02	1.15E+01	3.79E-01	2.22E+02	1.03E-02	-2.10E+00*
Depletion potential of the stratospheric ozone layer, (ODP)	kg CFC-11 eq.	8.54E-06	5.01E-07	3.20E-08	9.08E-06	2.10E-11	0.00E+00
Acidification potential (AP)	kg SO_2 eq.	4.58E-01	6.90E-02	5.35E-03	5.32E-01	4.33E-05	0.00E+00
Eutrophication potential (EP)	kg PO_4^{3-} eq.	2.48E-01	1.48E-02	1.96E-03	2.65E-01	9.90E-06	0.00E+00
Formation potential of tropospheric ozone (POCP)	kg C_2H_4 eq.	6.85E-02	2.85E-03	4.69E-04	7.18E-02	2.12E-06	0.00E+00
Abiotic depletion potential – Elements	kg Sb eq.	9.46E-04	1.42E-04	3.11E-06	1.09E-03	4.14E-10	0.00E+00
Abiotic depletion potential – Fossil resources	MJ, net calorific value	1.31E+03	1.58E+02	4.18E+00	1.47E+03	1.46E-01	0.00E+00

* *Only the carbonation of the product is considered in the use phase as it is strongly related to the calcination in A1 (net CO_2 emission) and the CO_2 uptake is calculated for 50 years.*

Use of resource

Results per tonne insulated precast concrete, sandwich wall								
Indicator		**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Primary energy resources – Renewable	Use as energy carrier	MJ, net calorific value	3.73E+02	3.80E+00	5.90E+01	4.36E+02	1.96E-04	0.00E+00
	Used as raw materials	MJ, net calorific value	7.71E-01	0.00E+00	0.00E+00	7.71E-01	0.00E+00	0.00E+00
	TOTAL	MJ, net calorific value	3.74E+02	3.80E+00	5.90E+01	4.37E+02	1.96E-04	0.00E+00
Primary energy resources – Non-renewable	Use as energy carrier	MJ, net calorific value	1.56E+03	1.69E+02	4.92E+00	1.73E+03	1.56E-01	0.00E+00
	Used as raw materials	MJ, net calorific value	6.55E+01	0.00E+00	0.00E+00	6.55E+01	0.00E+00	0.00E+00
	TOTAL	MJ, net calorific value	1.62E+03	1.69E+02	4.92E+00	1.80E+03	1.56E-01	0.00E+00
Secondary material		kg	4.08E+01	0.00E+00	0.00E+00	4.08E+01	0.00E+00	0.00E+00
Renewable secondary fuels		MJ, net calorific value	3.91E+01	0.00E+00	0.00E+00	3.91E+01	0.00E+00	0.00E+00
Non-renewable secondary fuels		MJ, net calorific value	8.60E+01	0.00E+00	0.00E+00	8.60E+01	0.00E+00	0.00E+00
Net use of fresh water		m^3	7.98E+01	2.51E-01	4.67E-02	8.01E+01	3.99E-05	0.00E+00

Waste production and output flows

Waste production

Results per tonne insulated precast concrete, sandwich wall							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Hazardous waste disposed	kg	5.86E-03	1.32E-04	8.50E-06	6.00E-03	0.00E+00	0.00E+00
Non-hazardous waste disposed	kg	2.29E+01	4.48E-01	1.35E-01	2.35E+01	1.29E-08	0.00E+00
Radioactive waste disposed	kg	3.47E-03	2.70E-04	2.06E-05	3.76E-03	0.00E+00	0.00E+00

Output flows

Results per tonne insulated precast concrete, sandwich wall							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Components for re-use	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Material for recycling	kg	5.36E-03	0.00E+00	3.14E+00	3.15E+00	0.00E+00	0.00E+00
Materials for energy recovery	kg	1.10E-02	0.00E+00	6.04E+00	6.06E+00	0.00E+00	0.00E+00
Exported energy, electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

5.4 Calculation results per tonne solid precast concrete, pre-stressed, slab element

Potential environmental impact

Results per tonne solid precast concrete, pre-stressed, slab elements							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Global warming potential (GWP)	kg CO_2 eq.	1.35E+02	6.98E-01	0.00E+00	1.36E+02	1.03E-02	-2.93E+00*
Depletion potential of the stratospheric ozone layer, (ODP)	kg CFC-11 eq.	3.47E-06	9.80E-08	0.00E+00	3.57E-06	2.10E-11	0.00E+00
Acidification potential (AP)	kg SO_2 eq.	1.54E-01	2.54E-03	0.00E+00	1.56E-01	4.33E-05	0.00E+00
Eutrophication potential (EP)	kg PO_4^{3-} eq.	5.91E-02	5.98E-04	0.00E+00	5.97E-02	9.90E-06	0.00E+00
Formation potential of tropospheric ozone (POCP)	kg C_2H_4 eq.	1.79E-02	9.19E-05	0.00E+00	1.80E-02	2.12E-06	0.00E+00
Abiotic depletion potential – Elements	kg Sb eq.	1.24E-04	9.40E-06	0.00E+00	1.33E-04	4.14E-10	0.00E+00
Abiotic depletion potential – Fossil resources	MJ, net calorific value	4.11E+02	1.04E+01	0.00E+00	4.21E+02	1.46E-01	0.00E+00

** Only the carbonation of the product is considered in the use phase as it is strongly related to the calcination in A1 (net CO_2 emission) and the CO_2 uptake is calculated for 50 years.*

Use of resources

Results per tonne solid precast concrete, pre-stressed, slab elements								
Indicator		**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Primary energy resources – Renewable	Use as energy carrier	MJ, net calorific value	2.30E+02	2.86E-01	0.00E+00	2.30E+02	1.96E-04	0.00E+00
	Used as raw materials	MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TOTAL	MJ, net calorific value	2.30E+02	2.01E+01	0.00E+00	2.50E+02	1.96E-04	0.00E+00
Primary energy resources – Non-renewable	Use as energy carrier	MJ, net calorific value	5.97E+02	1.07E+01	0.00E+00	6.07E+02	1.56E-01	0.00E+00
	Used as raw materials	MJ, net calorific value	1.54E+01	0.00E+00	0.00E+00	1.54E+01	0.00E+00	0.00E+00
	TOTAL	MJ, net calorific value	6.12E+02	1.07E+01	0.00E+00	6.23E+02	1.56E-01	0.00E+00
Secondary material		kg	1.39E+01	0.00E+00	0.00E+00	1.39E+01	0.00E+00	0.00E+00
Renewable secondary fuels		MJ, net calorific value	8.09E+01	0.00E+00	0.00E+00	8.09E+01	0.00E+00	0.00E+00
Non-renewable secondary fuels		MJ, net calorific value	1.17E+02	0.00E+00	0.00E+00	1.17E+02	0.00E+00	0.00E+00
Net use of fresh water		m^3	3.45E+00	1.45E-02	0.00E+00	3.46E+00	3.99E-05	0.00E+00

Waste production and output flows

Waste production

Results per tonne solid precast concrete, pre-stressed, slab elements							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Hazardous waste disposed	kg	3.69E-03	8.52E-06	0.00E+00	3.70E-03	0.00E+00	0.00E+00
Non-hazardous waste disposed	kg	1.00E+00	2.94E-02	0.00E+00	1.03E+00	1.29E-08	0.00E+00
Radioactive waste disposed	kg	3.31E-03	1.44E-05	0.00E+00	3.32E-03	0.00E+00	0.00E+00

Output flows

Results per tonne solid precast concrete, pre-stressed, slab elements							
Indicator	**Unit**	**A1**	**A2**	**A3**	**Tot.A1-A3**	**A4**	**B1**
Components for re-use	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Material for recycling	kg	1.31E-04	0.00E+00	2.46E-01	2.46E-01	0.00E+00	0.00E+00
Materials for energy recovery	kg	0.00E+00	0.00E+00	4.59E+00	4.59E+00	0.00E+00	0.00E+00
Exported energy, electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

6 Interpretation of LCA results

6.1 Interpretation of solid precast balcony, access balcony, beams and columns LCA results

Environmental impact for 1 tonne of precast product is mainly caused by module A1, see Figure 4. Module A2 contributes marginally to the parameters, and the contribution from A3 and A4 is almost insignificant. B1 has a marginal positive impact on the global warming potential, which is shown as a negative bar in the figure.

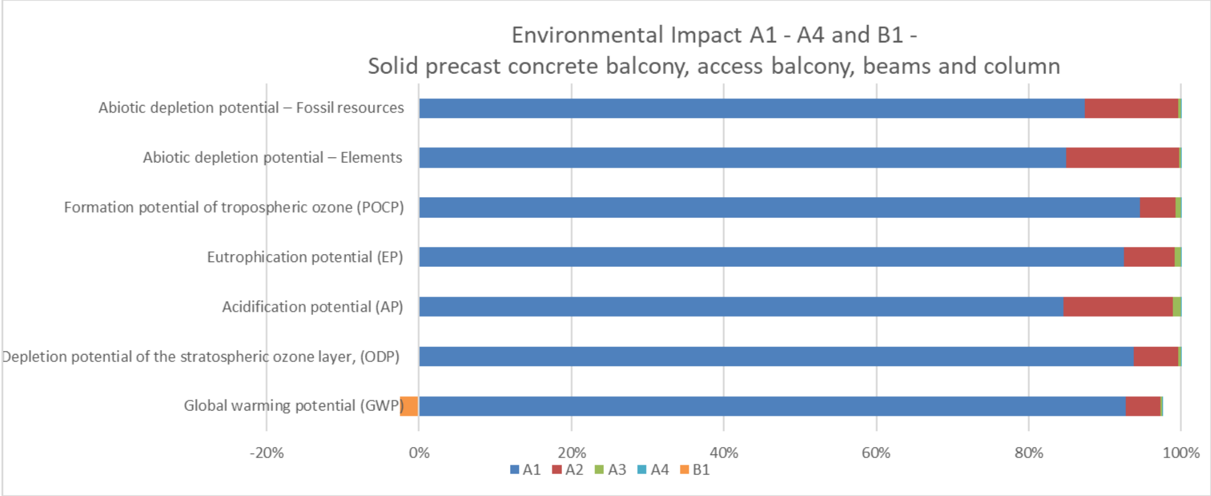

Figure 4. Figure of the contributions from the environmental impacts in A1-A4 and B1 for solid precast concrete balcony, access balcony, beams and columns.

Module A1 also consumes the majority of resources and produces the majority of the waste compared to Module A2-A4.

Within module A1, the extraction and processing of cement and iron reinforcement used in the product is the main contributor to the environmental impact, see Figure 5. Impact in A1 is further increases by produced waste mainly in the form of reinforcement and wood. Impact from other waste in the process is insignificant. The water used in the products is drawn from the groundwater. In the area where the manufacturing takes place, the water supply is deemed as good and water scarcity is not an issue.

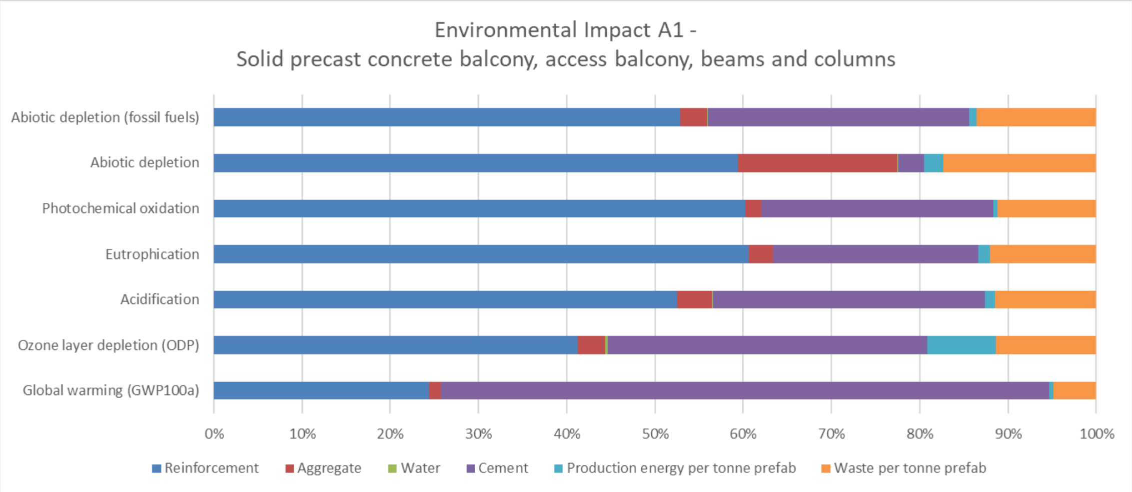

Figure 5. Figure of the contributions from the environmental impacts in A1 for solid precast concrete balcony, access balcony, beams and columns.

6.2 Interpretation of solid precast concrete wall LCA results

Environmental impact for 1 tonne of precast product is mainly caused by module A1, see Figure 6. Module A2 contributes marginally to the parameters, and the contribution from A3 and A4 is almost insignificant. B1, has a marginal positive impact on the global warming potential, which is shown as a negative bar in the figure.

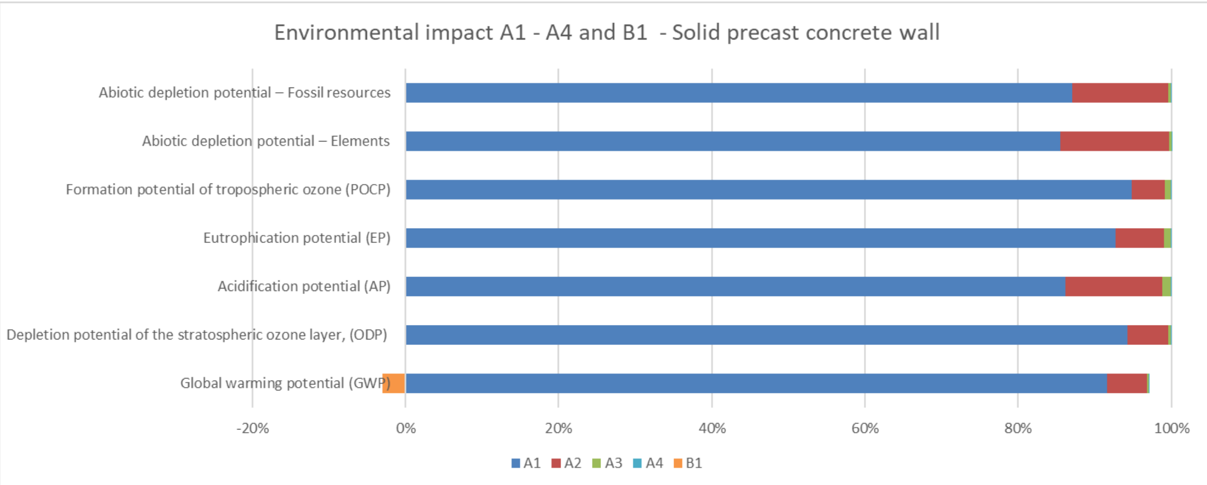

Figure 6. Figure of the contributions from the environmental impacts in A1-A4 and B1 for solid precast concrete walls.

Module A1 also consumes the majority of resources and produces the majority of the waste compared to Module A2-A4.

Within module A1, the extraction and processing of cement and iron reinforcement used in the product is the main contributor to the environmental impact, see Figure 7. Impact in A1 is further increases by produced waste mainly in the form of reinforcement and wood. Impact from other waste in the process is insignificant. The water used in the products is drawn from the groundwater. In the area where the manufacturing takes place, the water supply is deemed as good and water scarcity is not an issue.

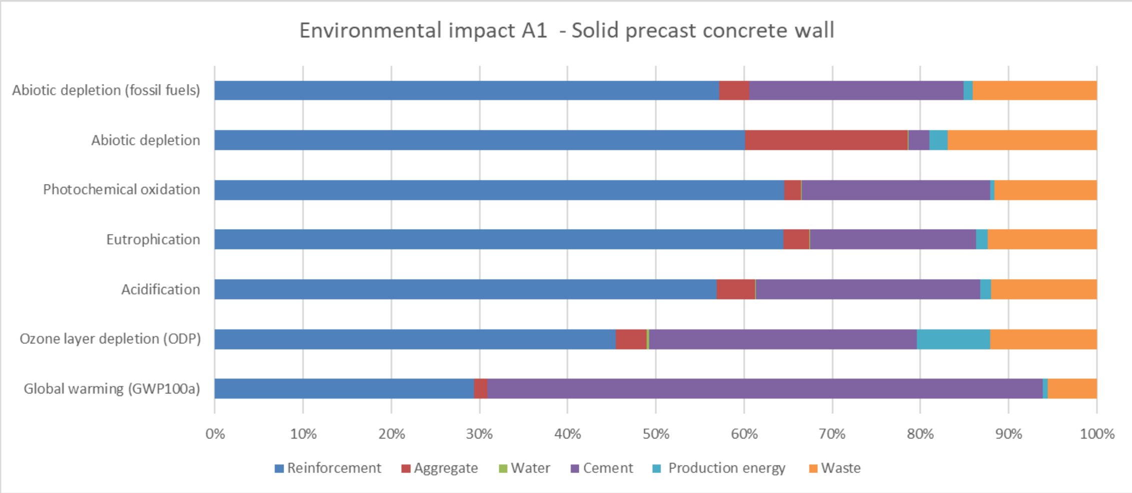

Figure 7. Figure of the contributions from the environmental impacts in A1 for solid precast concrete walls.

6.3 Interpretation of insulated precast concrete sandwich wall LCA results

Environmental impact for 1 tonne of precast product is mainly caused by module A1, see Figure 8**.** Module A2 contributes marginally to the parameters, and the contribution from A3 and A4 is almost insignificant. B1, has a marginal positive impact on the global warming potential, which is shown as a negative bar in the figure.

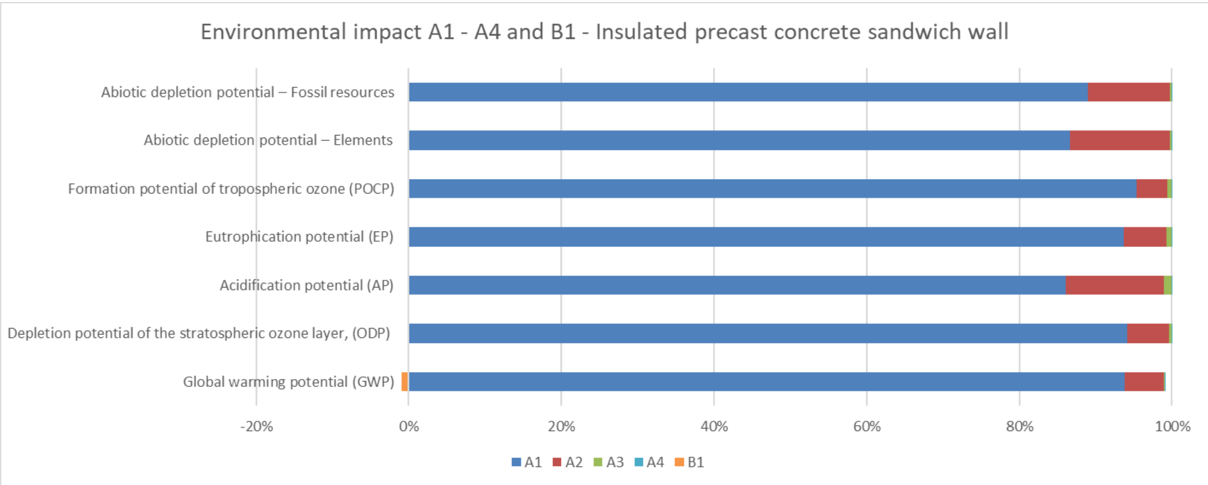

Figure 8. Figure of the contributions from the environmental impacts in A1-A4 and B1 for insulated precast concrete sandwich walls.

Module A1 also consumes the majority of resources and produces the majority of the waste compared to Module A2-A4.

Within module A1, the extraction and processing of cement and iron reinforcement used in the product is the main contributor to the environmental impact, see Figure 9. Impact in A1 is further increases by produced waste mainly in the form of reinforcement and wood. Impact from other waste in the process is insignificant. The water used in the products is drawn from the groundwater. In the area where the manufacturing takes place, the water supply is deemed as good and water scarcity is not an issue.

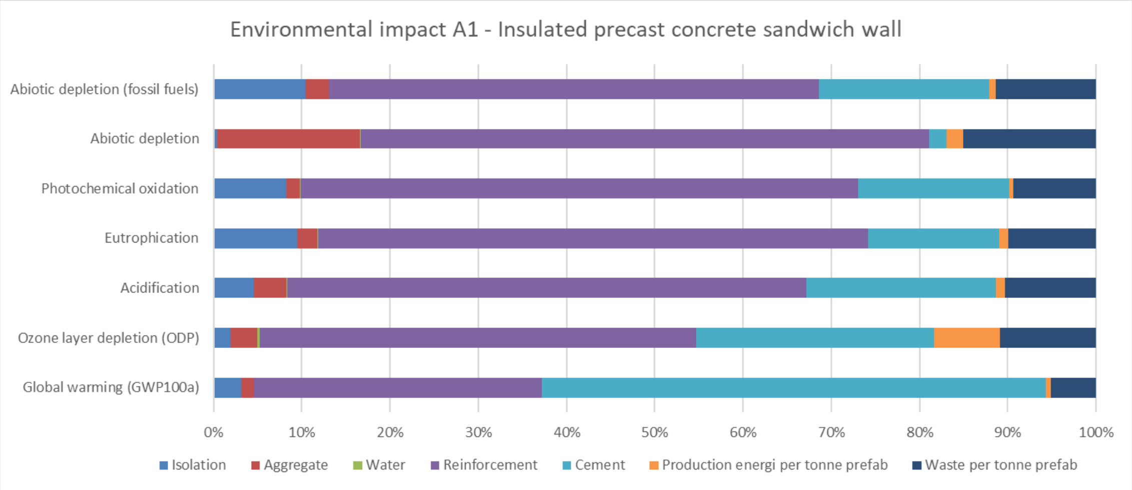

Figure 9. Figure of the contributions from the environmental impacts in A1 for insulated precast concrete sandwich walls.

6.4 Interpretation of solid precast concrete, pre-stressed, slab elements LCA results

Environmental impact for 1 tonne of precast product is mainly caused by module A1, see Figure 10**.** Module A2 contributes marginally to the parameters, and the contribution from A3 and A4 is almost insignificant. B1 has a marginal positive impact on the global warming potential, which is shown as a negative bar in the figure.

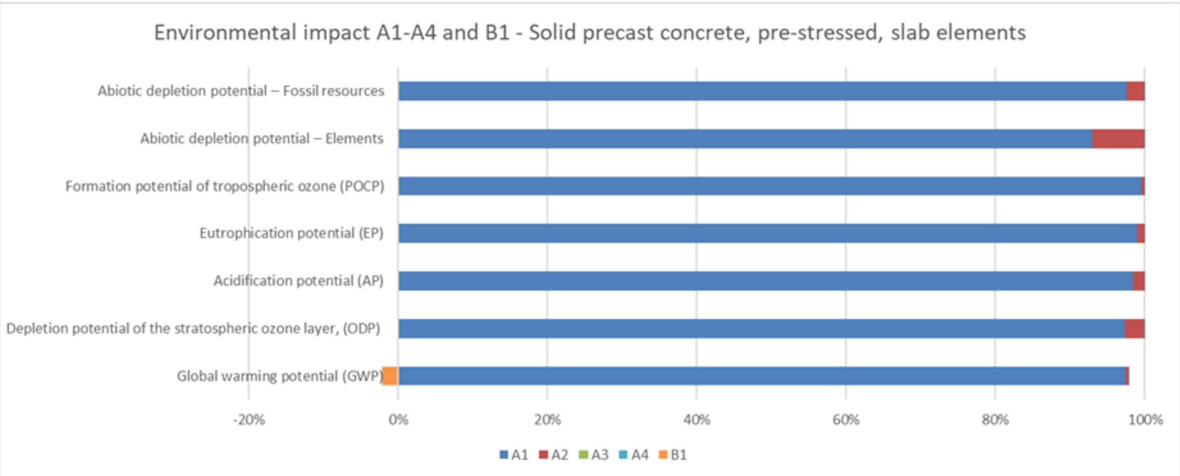

Figure 10. Figure of the contributions from the environmental impacts in A1-A4 and B1 for solid precast conrete, pre-stressed, slab elements.

Module A1 also consumes the majority of resources and produces the majority of the waste compared to Module A2-A4.

Within module A1, the extraction and processing of concrete used in the product is the main contributor to the environmental impact, see Figure 11. Impact in A1 is further increases by produced waste mainly in the form of reinforcement and wood. Impact from other waste in the process is insignificant. The water used in the products is drawn from the groundwater. In the area where the manufacturing takes place, the water supply is deemed as good and water scarcity is not an issue.

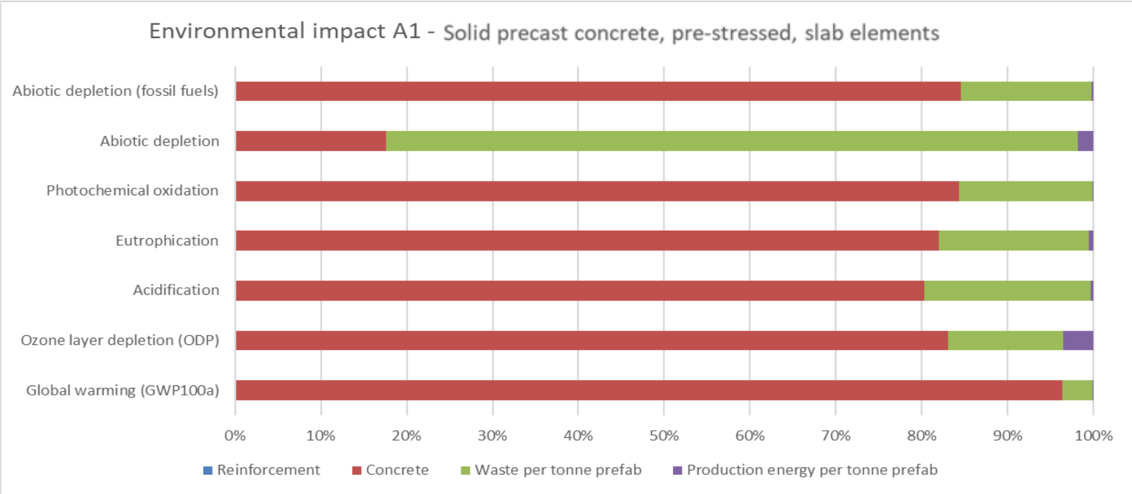

Figure 11. Figure of the contributions from the environmental impacts in A1 for solid precast conrete, pre-stressed, slab elements.

7 References

General Programme Instructions of the International EPD® System. Version 3.0.

SS-EN 15804:2012 Sustainability of construction works – Environmental product declarations – Product Category Rules for concrete and concrete elements

PCR 2012:01. Construction products and construction services. V2.33
PCR 2012:01-Sub-PCR-G

Svensk standard SS-EN 16757:2017 Sustainability of construction works – Environmental product declarations – Product Category Rules for concrete and concrete elements

Ecoinvent 3.6 database, http://www.ecoinvent.org/
Agri-footprint database, https://www.agri-footprint.com/

LCA software SimaPro Analyst 9.1.1.1

Material Safety Data sheets for:

- Superplasticizer masterglenium Ace 435
- Air-entraining admixtures Masterair 100
- Dynamon SX-A170