Value chain analysis

Ready-mixed concrete

May 2025

Version	B – Update following the CO2 logic review
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Contents

1. Introduction

N.V. BESIX S.A is part of BESIX Group, a multidisciplinary construction group specialized in the realization of buildings, infrastructure, sports & leisure, industry, environment and marine works, which are often distinguished by their complexity.

Through its wide range of projects BESIX acknowledges the significance of its carbon footprint within SCOPE 3. Yet, this scope is intricately linked to an entire supply & production chain and influenced by decisions made by both customers upstream as suppliers & subcontractors downstream.

Concrete, a key material in BESIX's structural projects, is valued for its technical characteristics and foundation benefits. Despite its advantages, it stands out as one of the most carbon-intensive materials. In BESIX's project several types of concrete are used, from ready-mixed concrete cast on site to prefabricated concrete delivered by suppliers, passing by road concrete and earth concrete. This value chain analysis focuses on ready-mixed concrete.

The pivotal question arises: How can BESIX tackle this environmental challenge and contribute in the effort to achieving global net zero by no later than 2050? This document aims to delve into this inquiry by conducting a comprehensive analysis of the value chain related to the use of ready-mixed concrete. This study highlights the stakeholders; life cycle stages and identifies the greenhouse gas emissions throughout the entire value chain related to the production of ready-mixed concrete and its application in our activities.

This value chain analysis is drawn up as part of the level 5 CO2 performance ladder certification of N.V. BESIX S.A.

1.1 What is a value chain analysis?

A value chain analysis is a way of evaluating each of the activities in a company's life cycle of a product to understand where opportunities for improvement, in this case reduction of GHG emissions, lie.

The value chain analysis is structured as this document describes the following elements:

- Description of the value chain in question
- Determination which life cycle categories are relevant
- Identification of the value chain partners
- Quantification of the scope 3 emissions for each relevant life cycle category
- Description of measures which can be taken by BESIX to reduce the carbon footprint

1.2 Choice of this value chain analysis within BESIX

As part of the CO2 performance ladder certification BESIX has reviewed in the second semester of 2024 its scope 3 analysis, both quantitative as qualitative, to redefine the most relevant scope 3 emission categories.

Considering the composition of the scope 3 category 'Purchased Goods & Services' over the last 5 years (see below extract from the CO2 software application Smarttrackers), ready-mixed concrete is in absolute values a top 3 contributor amongst rebar and MEP.

Considering the importance in the sector and the potential influence both the sector and BESIX can have on reducing the emissions, ready-mixed concrete and rebar are considered as the 2 most relevant scope 3 categories.

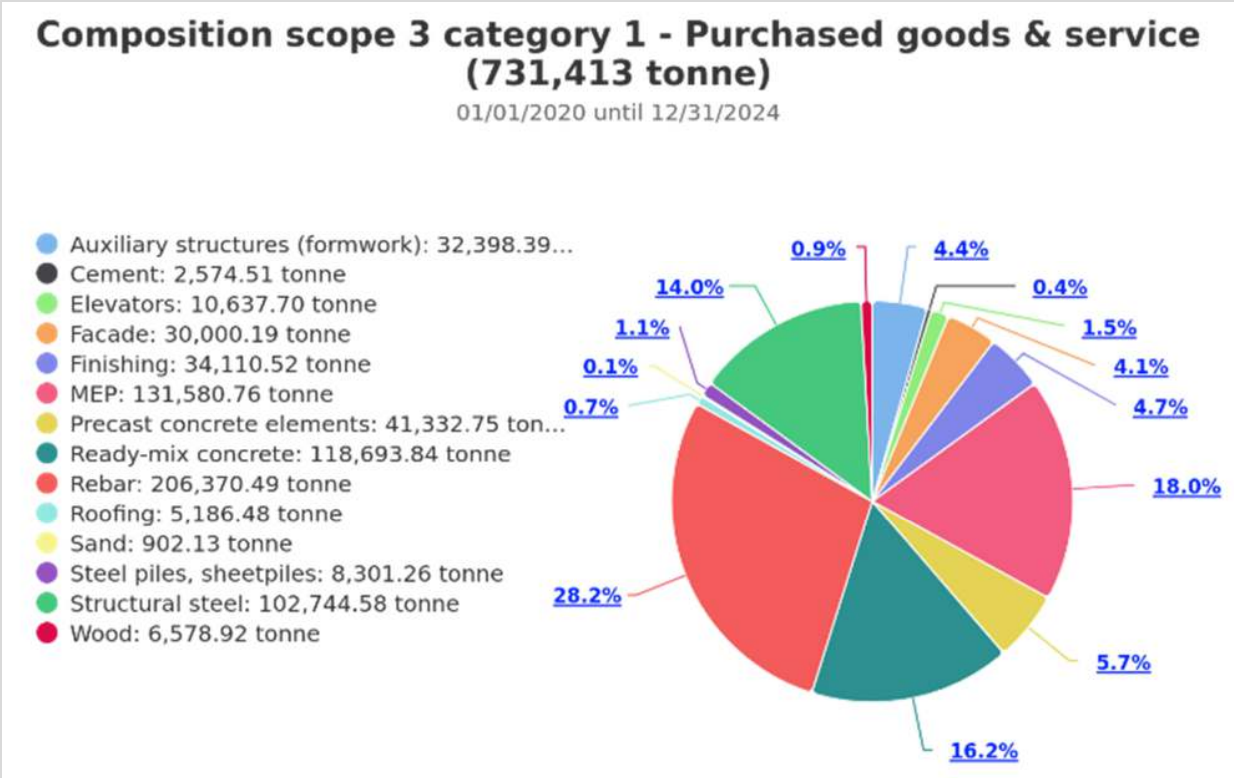


Figure 1

1.3 Goal of this value chain analysis

This value chain analysis must be seen as a continuation of the value chain analysis 'Ready-mixed concrete' written in 2017 in collaboration with KWA Bedrijfsadviseurs and which was updated in 2022. While the value chain analysis in 2017 and 2022 focused on the application of ready-mixed concrete on the projects in the Netherlands, the current value chain analysis focuses on Belgian projects.

The goal of this analysis is to identify and analyze the value chain of ready-mixed concrete and determine how BESIX can have an impact in the value chain over the entire life cycle, both upstream as downstream. By understanding the entire production process of ready-mixed concrete, from raw materials acquisition over the application of the final product in construction projects to its end-of-life treatment, BESIX aims to determine the actions and opportunities it can take to reduce the carbon footprint of this product. It also aims to define reduction targets and the process to monitor progress.

1.4 Boundary of the analysis

The data collected for this value chain is limited to N.V. BESIX S.A. for the entities and projects located in the BENELUX and France. In this value chain analysis, specific data and information of the following ready-mixed suppliers has been used:

- AC Materials
- CCB
- CMIX
- De Rycke beton
- Declercq Stortbeton
- Heiderlberg Materials
- Holcim
- Readybeton
- Albeton Arkersloot BV
- Dyckerhoff Basal
- Multimix
- Ready beton
- Unibeton

The value chain analysis has been performed for 2023 and 2024 data.

2. Value chain identification

The concrete value chain is a complex and interconnected system involving multiple stakeholders, including raw material suppliers, ready-mix concrete manufacturers, construction companies, transportation providers and regulatory bodies.

In addition to the life cycle of ready-mix concrete—from raw material extraction to end-of-life processing—two other key processes significantly impact its overall footprint. The first is the tendering phase, where the client sets the project's sustainability ambitions. The second is the design phase, where optimization strategies are being explored, and concrete mixes are being designed. While these processes are not included in the direct quantification of value chain emissions, they are addressed separately, as BESIX can play a crucial role in both.

This means that the value chain looks as follows:

Figure 2

The LCA boundaries from the extraction of raw materials to end-of-life processing is broken down in the picture bellow. The system which will be studied is the value chain of concrete from the raw materials supply who are needed to the end-of-life. The global warming potential (GWP) is going to be analyzed for the different steps.

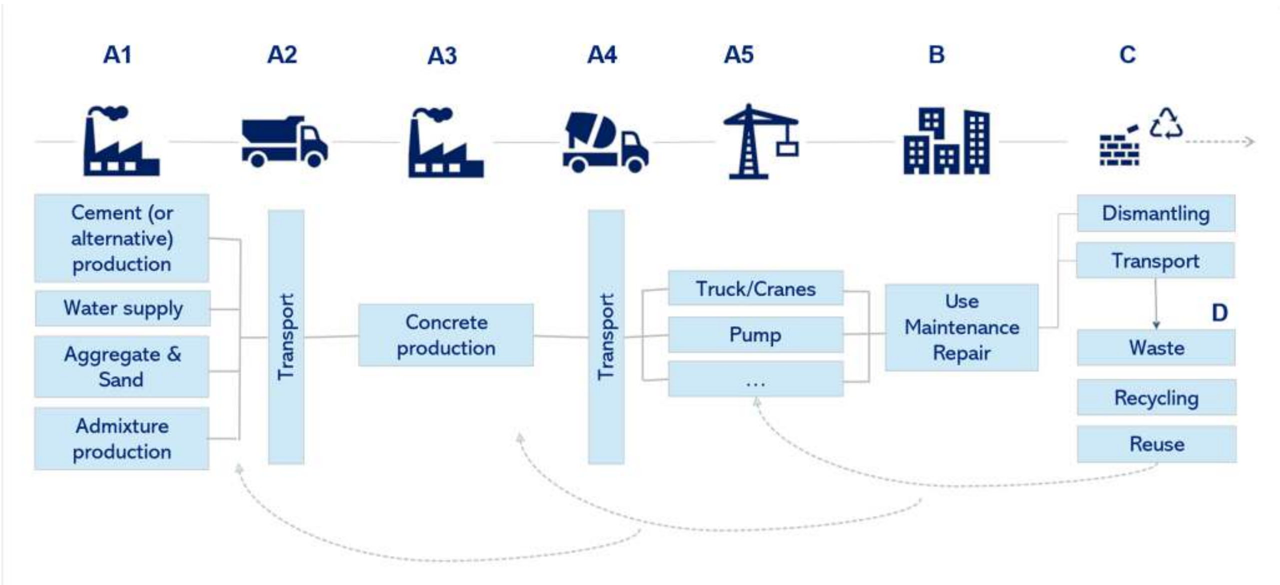


Figure 3

Rebar used as reinforcement in concrete structures is not taken into account in this value chain analysis. The application of rebar is part of a separate value chain analysis.

2.1 Value chain partners

In the concrete value chain, there are different contributors at each step. This section describes the players in the chain. Collaboration between the stakeholders in the concrete sector is the key to reduce the material's carbon footprint, by sharing knowledge, best practices and adopting innovative technologies.

- ✓ Policy makers (European Union, Governments (national/regional)

  Due to the regulatory nature (climate policy, energy policy, building regulations,...) of both the European Union as well as the national and regional governments of the various member states, there is an active drive towards CO2 reduction within the industry and thus also the construction sector.

  From the European Union, various measures have been taken within the European Green Deal to reduce the emissions within the construction sector. Examples include the Climate Act, ETS mechanisms for specific sectors and recently for road transport and buildings, the Energy Efficiency Directive,....

  Member states and/or regions can also individually implement additional legislation which has a direct impact on making the construction sector more sustainable. Examples include the Green Deal 'Sustainable Concrete' which led to the 'Concrete Agreement' in the Netherlands, the 'Circular Concrete Agreement' in Flanders or the so-called 'concrete stop' in the Flanders Spatial Policy Plan which aims to ensure that by half the amount of open space disappears by 2025 and that this disappearance stops by 2040. This implies that more and more efforts will be made to renovate and reuse materials from the related demolition work.

- ✓ Research, certification and standardization

  By drafting and updating product standards, accreditation organizations can facilitate CO2 reduction within the construction sector. We are thinking here of adjusting product standards on concrete in function of technological and innovative developments within the sector. Examples include enabling the application of innovative binders and increasing the percentage of allowable aggregates and additives in applicable product standards.

  Through participation in sector initiatives such as the Concrete Agreement in the Netherlands and the Circular Concrete Accord Flanders, efforts are being made to adapt existing standards in function of these innovative developments. The General Contractor, alongside the government, concrete and raw material suppliers have an important role to play here. The academic world, whether or not in cooperation with the construction industry, is actively looking for solutions to make concrete mix and/or its application further sustainable.
  Examples include initiatives around 3D printing (e.g. 3D2BGreen,...), the use of alternative binding agents, extending the life cycle of concrete (b. Smartincs self-healing concrete), ...

- ✓ Client

  By defining the sustainability ambition level of the project, the Client has a major impact in reducing the footprint of its building or structure. By choosing for more sustainable construction materials such as wood or low-carbon concrete and/or sustainable transportation methods the Client defines already in the tendering/early-design phase the footprint of its building or structure. Early Contractor Involvement with BESX is therefore important and can help the Client in making sustainable choices and drive innovation.

- ✓ Internal/external Engineers and architects :
  They design the structures and specify the concrete mixes. At the design stage, and the earlier they consider it, engineers and architects can reduce the project's carbon footprint. A number of techniques can be used, such as reducing the amount of required material by making the building slimmer, life cycle analysis, comparison of design concepts, optimization of concrete strength class, etc.

- ✓ Raw materials suppliers :
  Providers of raw materials such as aggregates, water and additives. They have an impact on the chain in the extraction practices to minimize the environmental footprint of quarrying raw materials such as aggregates. The impact of the raw material supplier is determined the location of the raw material extraction, transportation methodology of these raw materials and the energy used during the production phase. They can also reduce the need of new aggregates by opting for recycled materials.

- ✓ Cement manufacturers :
  As mentioned in figure 4 the Global Warming Potential of ready-mixed concrete is mainly determined by the type of binder and more specifically cement. They produce the cement, a primary component of concrete and therefore they play a significant role in determining the material's environmental footprint.

- ✓ Concrete mix producers:
  They combine the raw materials to produce concrete mix according to specific project requirements. With knowledge of the sector and their materials, concrete producers can work on a number of aspects to reduce environmental impact. Ready-mixed concrete suppliers which are situated along water ways can opt for transport over water for their base materials such as cement, sand and aggregates. They can also optimize their mix designs, by minimizing the amount of cement needed or using alternative binders (such as blast furnace cement instead of Portland cement) or by investing in the development of new mixes or mixes based on recycled aggregates.
  As product experts, they can distinguish themselves through innovation and advise their customers on how to move towards lower-carbon mixes.
  Also in the transport of the end product to their clients, the concrete mix suppliers can reduce their footprint by opting for alternative fuels (such as HVO, biogas, hydrogen,...) or electrification of their fleet of mixers.
  Finally, communication is important, and providing EPDs of their products is a key point so that other stakeholders can make coherent choices at their level.

- ✓ Construction companies
  They use the concrete in the projects. Via the procurement phase they play a strategic role. By choosing products with a low carbon footprint they can distinguish themselves from competitors. General Contractors with an internal engineering department can optimize the design of the structure to be built and also reducing the amount of required m^3 of ready-mixed concrete and/or rebar. This is certainly the case in design & build projects.
  Emission during the application of the ready-mixed concrete on site is mainly due to the energy use related to vertical transport and the use of concrete pumps, vibrating needles,.... By opting for renewable energy and optimization of execution methods (transport outside rush hours, approach routes,...) further optimization in CO2 reduction is possible.
  Finally, a point of attention that is also in their hands is the management of demolition and the flow of concrete at the end of its life.

- ✓ End user (buildings)
  Although the influence of an end-user is limited on the choice of materials while constructing a building, an end-user has an influence by choosing for more sustainable buildings.

- ✓ Demolition companies
  A demolition company plays a crucial role in the value chain of ready-mix concrete, particularly through the recycling and repurposing of construction and demolition (C&D) waste. By integrating recycled aggregates into the production of ready-mix concrete, demolition companies contribute to a circular economy. This process helps in reducing waste, conserving natural resources, and lowering carbon emissions associated with cement production

- ✓ Recycling and waste management companies :
  They will handle the concrete waste and find options for recycling. Finally, the last of the chain can foster the circular economy and therefore reduce the carbon footprint by facilitating the recycling and reuse of concrete.

All the stakeholders have also a common challenge to optimize the **energy efficiency** of their process and to minimize the **transport impact** between the different steps.

3. Quantification of the emissions

Based on the description of the value chain as shown in chapter 2, the CO_2 emissions are determined for each step in the value chain.

3.1 Product stage : A1-A3

This stage of the LCA refers to the material production. It is in the hand of the raw materials suppliers, the cement producer and the concrete producer. As BESIX is not a ready-mix concrete supplier, the analysis of the production phase (A1-A3) is limited to the concrete mixtures provided by the supplier. An internal analysis was carried out to determine the impact of concrete purchased from BESIX's suppliers with a focus on the projects in Belgium.

3.1.1 Raw materials

Ready-mixed concrete consists of about ¾ sand and aggregates (grit and stones to strengthen the concrete), ¼ of cement which serves as the binder used to shape the final concrete structure and water and admixtures. The environmental impact of ready-mixed concrete is mainly due to the use of cement which accounts for 95% of the climate impact of the concrete material.

The first graph below illustrates its composition by weight, which varies depending on factors such as strength class. The second graph provides an overview of the carbon footprint of the different components of ready-mixed concrete.

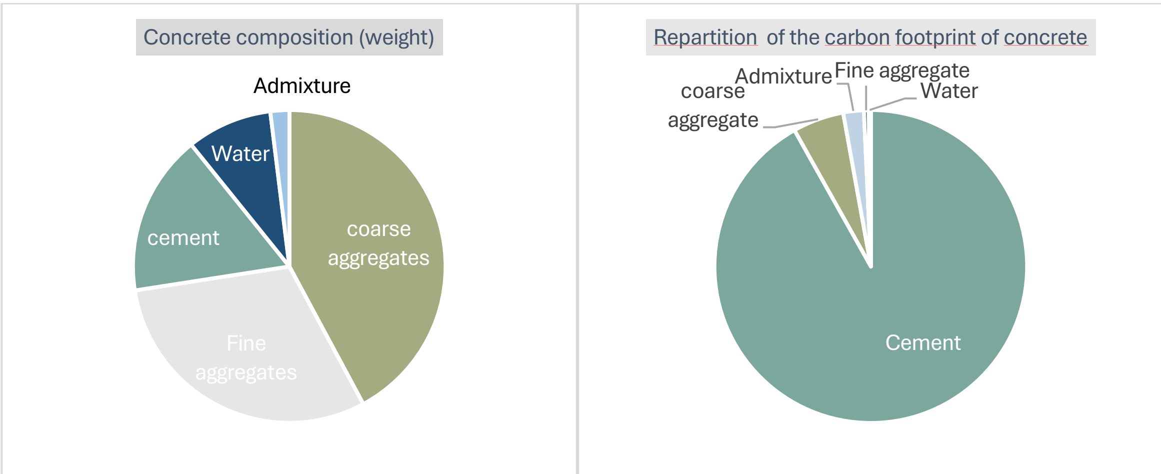


Figure 4

An important point to note is that cement production accounts for a significant portion of emissions, with approximately 60% resulting from the clinkerization process - the chemical reaction required to produce clinker. The remaining 40% comes from the energy needed to heat the kiln to 1,450°C to initiate this reaction. (Figure 5 - Production process of cement)

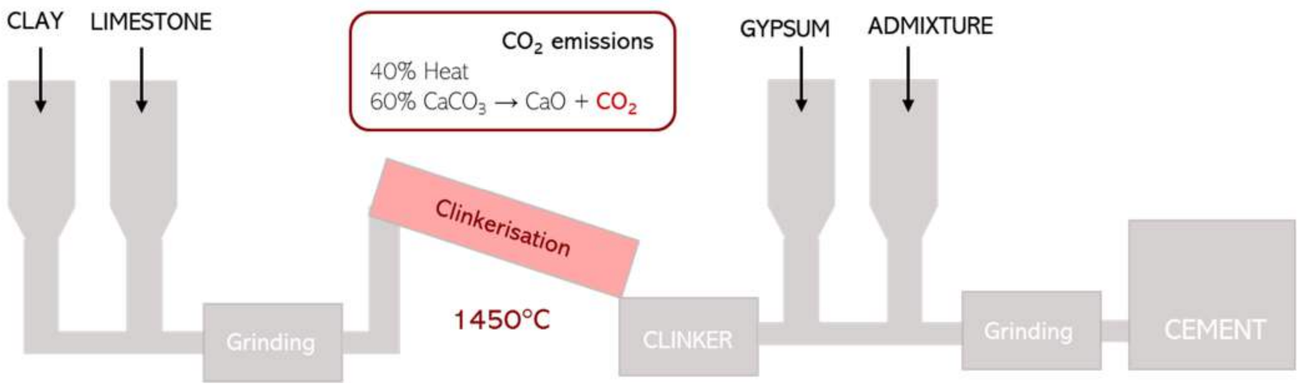


Figure 5 - Production process of cement

Sand and aggregates are usually extracted from stone and sand quarries. Traditional cement is made from Portland clinker (cement type CEM I), but large-scale cement types in which the CO2-intensive Portland clinker has been replaced by alternative raw materials (CEM II, IV and V) or the residual product blast furnace slag (CEM III).

To reduce emissions, the key solution is to transition away from traditional Portland cement and adopt alternative cements. This includes using blended cements with optimized compositions or innovative binders such as geopolymers and other emerging technologies.

The table[1] below shows the composition and % of clinker in the most frequently used cement types.

Designation	CEM I	CEM II/A	CEM III/A	CEM III/B	CEM IV	CEM V/A
Name / Composition	Portland cement	Compound Portland cement	Blast furnace cement		Pozzolanic cement	Compound cement
Clinker (K)	95-100%	80-94%	35-64%	20-40%	45-89%	40-64%
Blast furnace slag (S) [GGBS]			36-65%	60-80%	11-55%	18-30%
Fly Ash (V)						18-30%
Other	0-5%	0-5%	0-5%	0-5%	0-5%	0-5%

Table 1

[1] Source : https://www.concretedispatch.eu/blog/beton-bas-carbone/caracteristiques-des-ciments-courants.pdf

The graph[1] below shows the Global Warming Potential per cement type for the Life cycle categories A1 till A3:

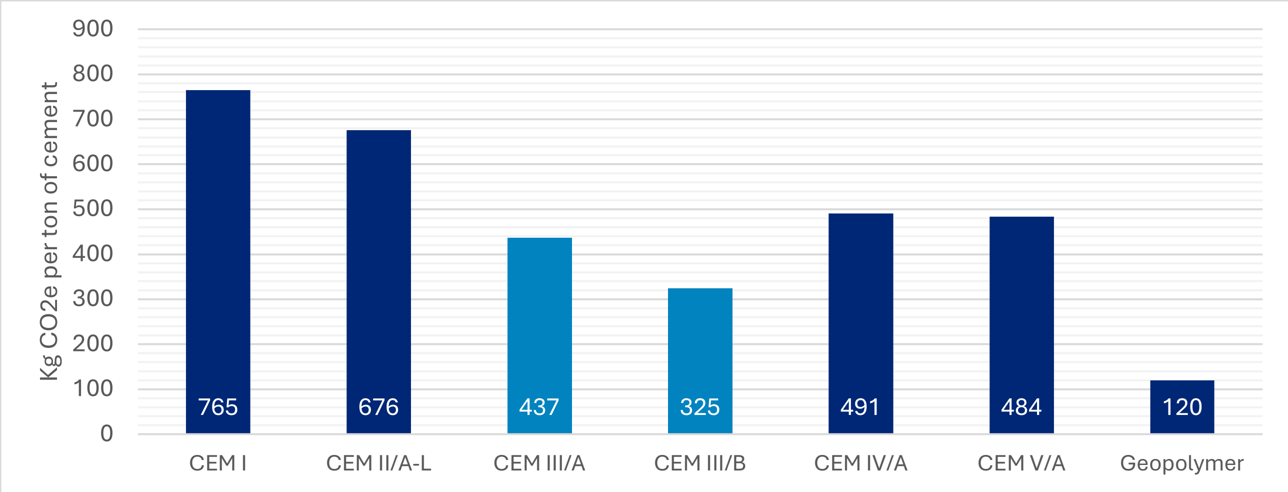


Figure 6

For each concrete strength class, the quantity of cement varies. Here's an indicative graph of the carbon footprint of concrete according to different cement categories and their quantity and each type of mix. This was computed according to the NBN B15-001 :

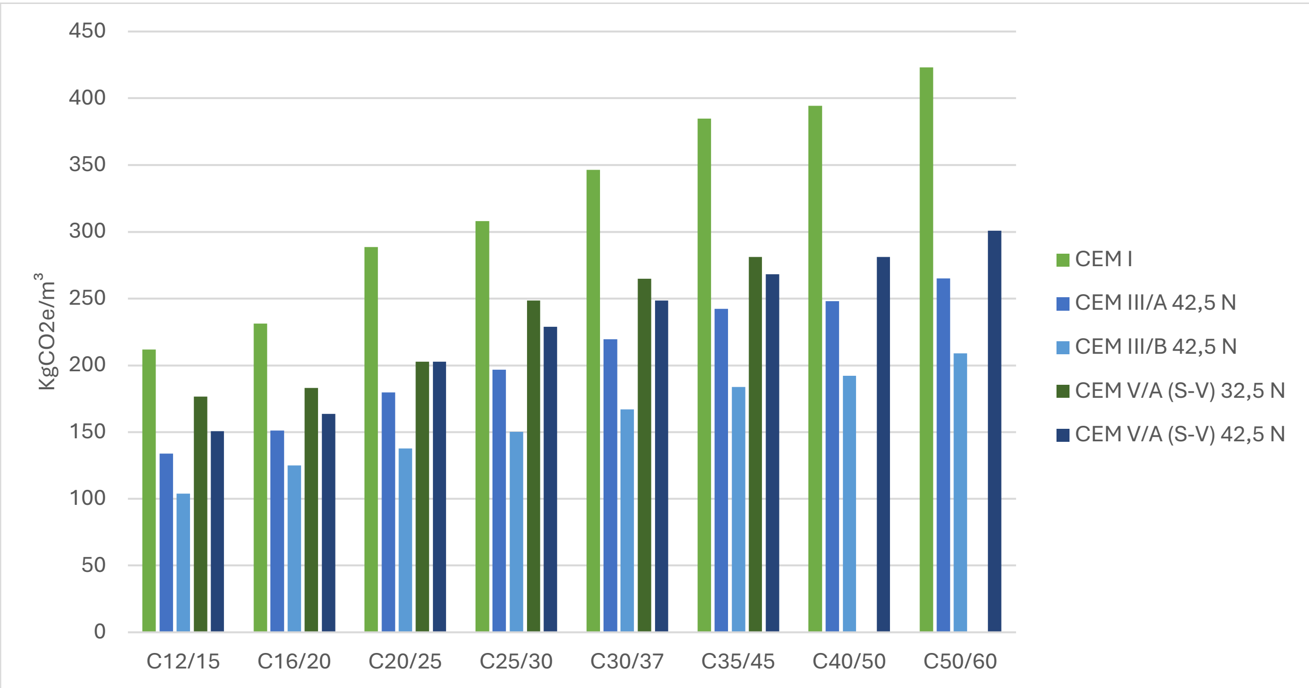


Figure 7

3.1.2 Assumptions of the carbon footprint

Our carbon footprint analysis is based on CO2 data by strength class and cement type. The values have been calculated on the basis of the carbon footprint of the cement and the quantity of cement in each mix. Considering a generic CO2 value for aggregates, admixtures and water (20 Kg CO2e).

Assumptions
no difference between environmental classes
no difference between different slump classes
no difference between different Dmax

This table shows the amount of cement in each concrete strength class according to the NBN B15-001 :

Assumptions cement content based on technical datasheets and NBN B15-001						
	CEM I	CEM II	CEM III/A 42,5 N	CEM III/B 42,5 N	CEM V/A (S-V) 32,5 N	CEM V/A (S-V) 42,5 N
C12/15	200	*200*	200	200	240	200
C16/20	220	*220*	230	250	250	220
C20/25	280	*280*	280	280	280	280
C25/30	300	*300*	310	310	350	320
C30/37	340	*340*	350	350	375	350
C35/45	380	*380*	390	390	400	380
C40/50	390	*390*	400	410		400
C50/60	420	*420*	430	450		430

Table 2

The 2 tables below shows the carbon footprint of the different types of cement. The values are based on EPDs when available and are estimated when needed. They shows the 2 types of cement production (wet process and dry process) :

dry process				
Cement type	Manufacturer	A1-A3 (KgCO2e/kg)	A4	Source
CEM I 52,5 R	CCB	0.769	0.270	EPD
CEM I 52,5 N	CCB	0.743	0.020	EPD
CEM II/A-LL	CCB	0.618	0.019	EPD
CEM III/A 42,5 N	CCB	0.465	0.026	EPD
CEM V/A (S-V) 32,5 N	CCB	0.549	0.020	generic
CEM V/A (S-V) 42,5 N	CCB	0.549	0.020	generic
CEMIIIA42.5/CEMV32.5	CCB	0.507	0.020	estimate
CEM32.5LA/CEMI52.5N	CCB	0.588	0.020	estimate

wet process				
Cement type	Manufacturer	A1-A3 (KgCO2e/kg)	A4	source
CEM I 52,5 N	Holcim	0.940	0.020	generic
CEM II		0.474		
CEM III/A 42,5 N	Holcim	0.550	0.020	generic
CEM III/B 42,5 N	Holcim	0.400	0.020	generic
CEM V/A (S-V) 32,5 I	Holcim	0.633	0.020	estimation for wet process
CEM V/A (S-V) 42,5 I	Holcim	0.633	0.020	generic
CEM I 52,5 R	Holcim	0.940	0.020	generic

Table 3

Cement production involves two main manufacturing processes: the wet process and the dry process. The dry process is increasingly favored due to its significantly lower carbon footprint. This is because, unlike the wet process which requires large amounts of energy to evaporate water from the raw slurry, the dry process grinds and blends dry raw materials, thus reducing the energy demand during kiln heating. Lower energy use translates directly to reduced fossil fuel consumption and greenhouse gas emissions, making the dry process a more environmentally sustainable option.

Finally, the two tables below show the carbon footprint calculated on the basis of the quantities of cement and the default value for the other components. One table is the worse case scenario because it is based on cement produced by the wet process and the other by the dry process.

In the tables, the red-highlighted boxes indicate solutions with a carbon footprint exceeding 200 kgCO_2e, representing the least environmentally favorable options.

Estimated CO2 (kg/m3)- dry process						
	CEM I	CEM II	CEM III/A 42,5 N	CEM III/B 42,5 N	CEM V/A (S-V) 32,	CEM V/A (S-V) 42,
C12/15	169	144	113	88	152	130
C16/20	183	156	127	105	157	141
C20/25	228	193	150	115	174	174
C25/30	243	205	164	126	212	196
C30/37	273	230	183	139	226	212
C35/45	302	255	201	153	240	229
C40/50	310	261	206	160		240
C50/60	332	280	220	173		256

Estimated CO2 (kg/m3)- worst case - wet process						
	CEM I	CEM II	CEM III/A 42,5 N	CEM III/B 42,5 N	CEM V/A (S-V) 32,	CEM V/A (S-V) 42,
C12/15	208		130	100	172	147
C16/20	227		147	120	178	159
C20/25	283		174	132	197	197
C25/30	302		191	144	242	223
C30/37	340		213	160	257	242
C35/45	377		235	176	273	261
C40/50	387		240	184		273
C50/60	415		257	200		292

Table 4

A cross-check with the data available on our Oneclick LCA tool was carried out. The following table summarizes the values used in our full analysis. By cross-referencing these two sources, we can validate our data and enhance its overall quality. Data reference for our carbon footprint :

Concrete strength class	Cement type	Carbon footprint (mean value A1-A3) [KgCO2e/m³]
C12/15	CEM I	188
	CEM II/A	183
	CEM III/A	122
	CEM III/B	94
	CEM V/A	151
C16/20	CEM I	205
	CEM II/A	156
	CEM III/A	137
	CEM III/B	113
	CEM V/A	160
C20/25	CEM I	256
	CEM II/A	193
	CEM III/A	162
	CEM III/B	124
	CEM V/A	185
C25/30	CEM I	272
	CEM II/A	193
	CEM III/A	177
	CEM III/B	135
	CEM V/A	219
C30/37	CEM I	306
	CEM II/A	230
	CEM III/A	198
	CEM III/B	150
	CEM V/A	235
C35/45	CEM I	340
	CEM II/A	255
	CEM III/A	218
	CEM III/B	164
	CEM V/A	251
C40/50	CEM I	348
	CEM II/A	261
	CEM III/A	223
	CEM III/B	172
	CEM V/A	256
C45/55	CEM I	*402*
	CEM II/A	*367*
	CEM III/A	*265*
	CEM III/B	*190*
	CEM V/A	260
C50/60	CEM I	373
	CEM II/A	280
	CEM III/A	238
	CEM III/B	187
	CEM V/A	274
C60/75	CEM I	482.21
	CEM III/B	364.47
C80/90	CEM I	483

Table 5

3.1.3 Results & graphs of our A1-A3 analysis

This study provides a better understanding of the A1-A3 carbon footprint of the use of ready-mixed concrete in our projects. The quantities collected are based on the supplier's information and reported amounts by projects. An overview of the main quantities per supplier can be found in annex.

This graphs shows the main quantities used at BESIX by type of cement:

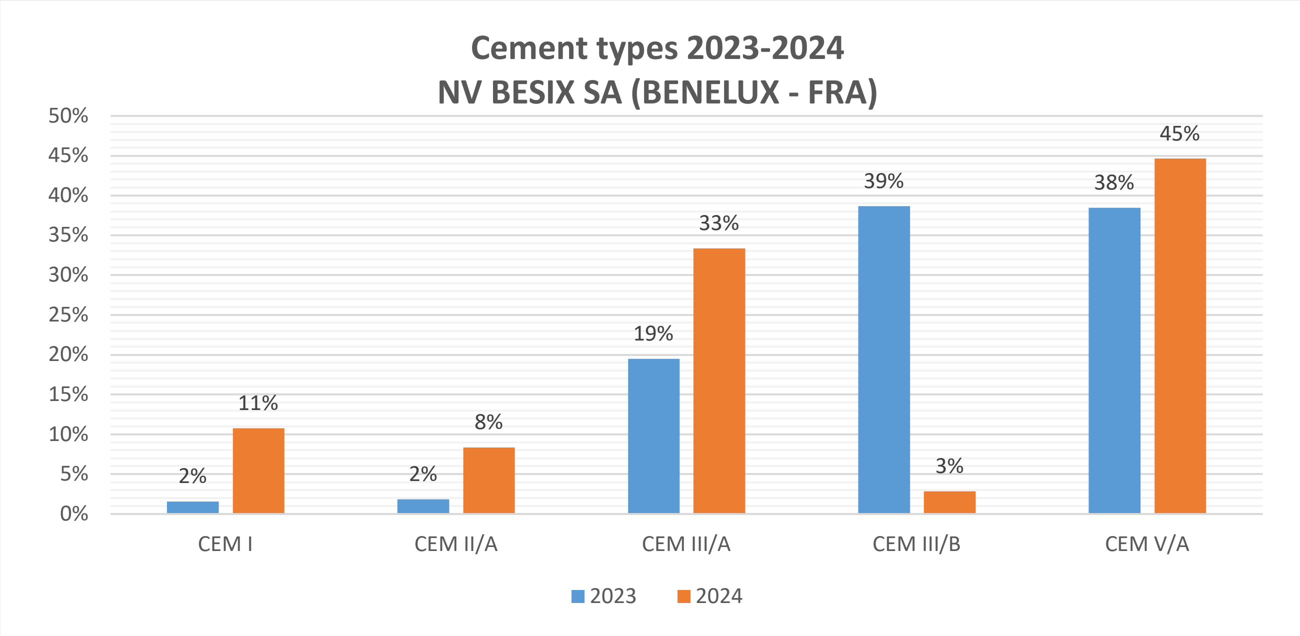


Figure 8

The use of CEM V/A is linked to specific projects, for example the Scheld tunnel in Antwerp as part of the Oosterweel project (TM COTU).

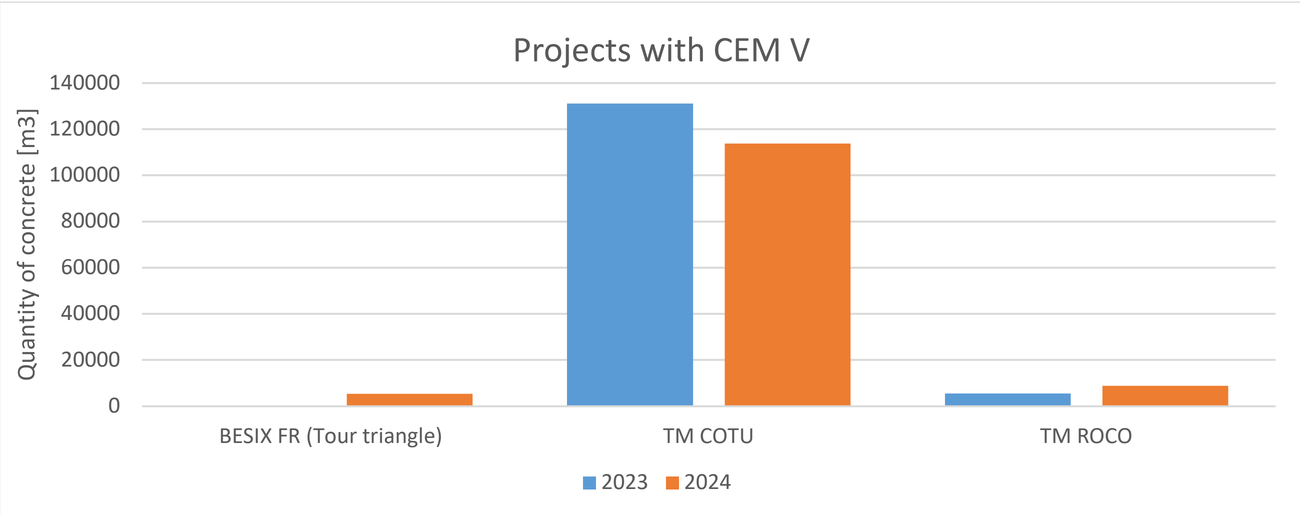


Figure 9

This following graphs shows the repartition of the type of cement use in BENELUX-FRA :

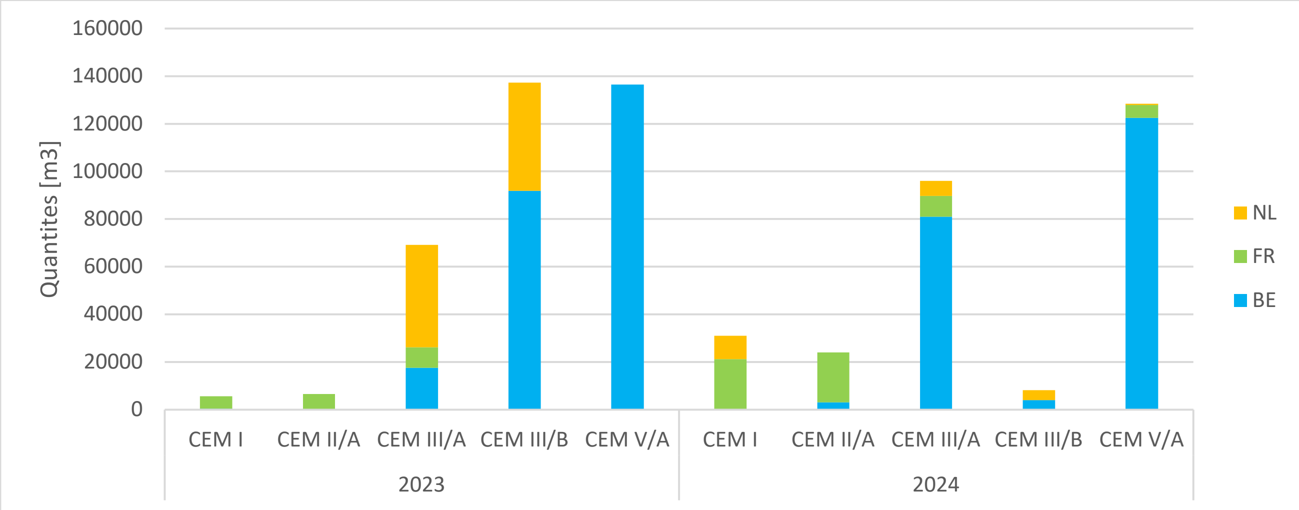


Figure 10

From this repartition we see that in France, CEM I and CEM II are more used than in Belgium and Netherlands. Depending on the project ongoing there is a variation in the cement types over the years. But CEM III and CEM V are mainly used.

This third graph summarizes the strength classes uses by BESIX in 2023-2024 :

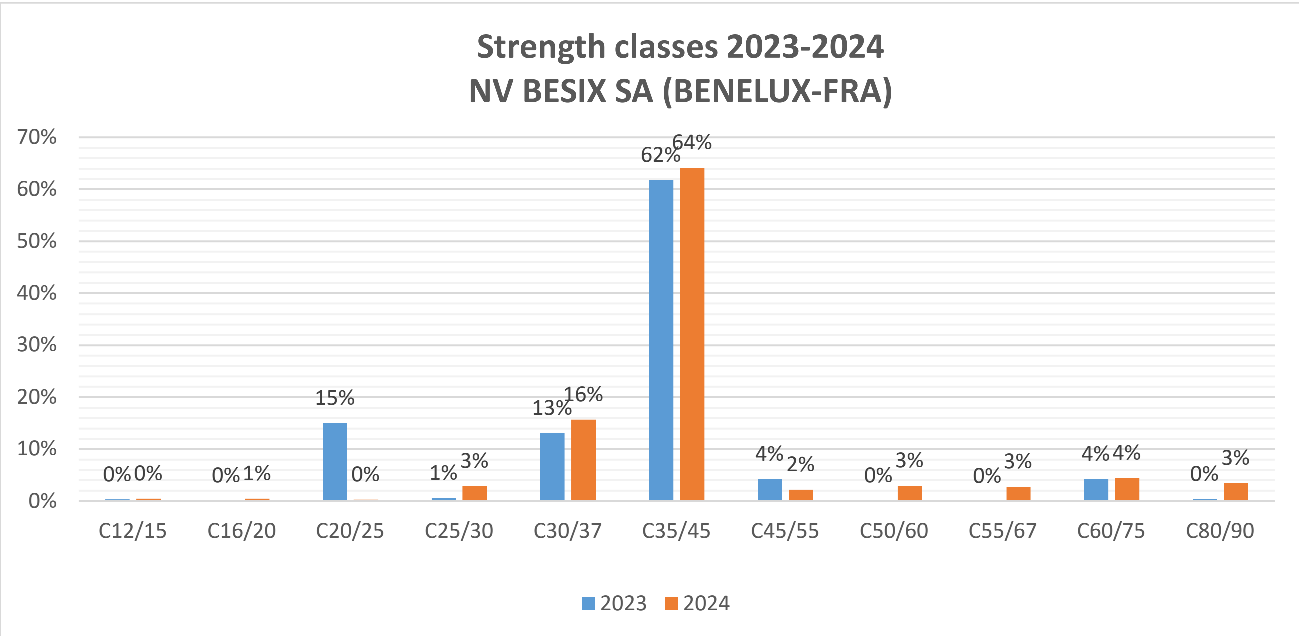


Figure 11

The most used concrete type is C35/45 and C30/37. Therefore our primary decarbonization strategy should be focus on these concrete mix types.

Another interesting point, is to understand the trend in the different countries :

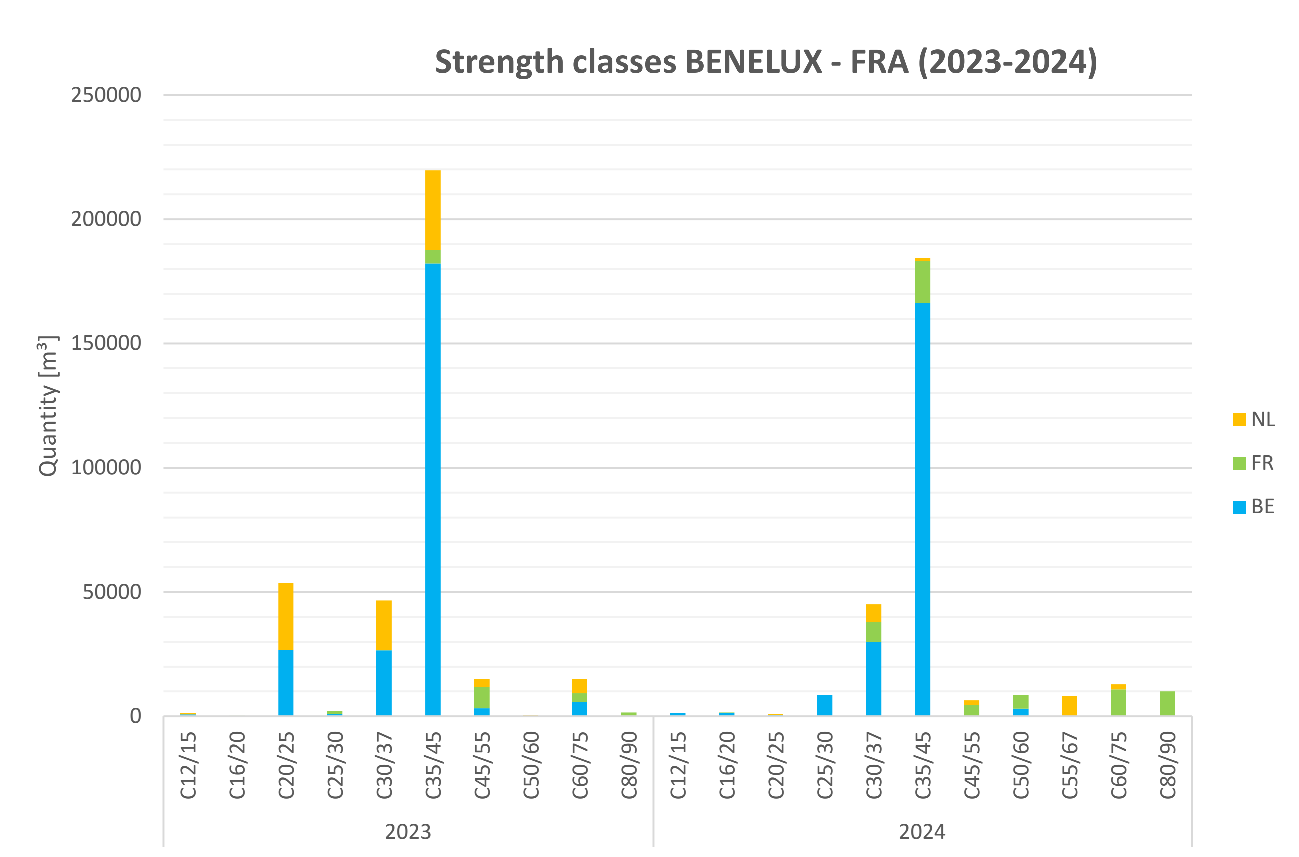


Figure 12

The high strength concrete present in the figure above are linked to a specific project in France (Tour triangle) where high strength concrete is needed due to technical reasons.

Now that the graphical trends have been presented, it is necessary to calculate the average CO_2 emissions per cubic meter for the analyzed years. These results allow us to monitor our performance and ensure that we are aligned with the KPIs previously defined and outlined later in this document.

The table shows the average carbon footprints for A1-A3 per entity per year. We can observe that some JV are accounted separately but theoretically they are in NV BESIX SA. These joint ventures are presented separately, as the projects span several years and are not solely dependent on BESIX's decisions. Due to their significance and specific nature, they are shown alongside the entities.

A1-A3

All Strength	2023			2024		
	Average kg CO2/m3	CO2 (KgCO2e)	Quantity (m3)	Average kg CO2/m3	CO2 (KgCO2e)	Quantity (m3)
BESIX FR	314	6 407 907	20 391	339	18 912 798	55 863
BESIX Nederland BV	229	40 477 736	176 933	247	5 081 206	20 609
BESIX NV	203	4 243 916	20 930	197	9 254 553	46 864
SM BESIX - GALERE	215	100 681	468	-	-	-
TM COTU	251	32 883 261	131 056	243	34 561 638	142 376
TM ROCO	251	1 391 014	5 546	219	5 253 542	23 956
Grand Total	**241**	**85 504 515**	**355 324**	**252**	**73 063 737**	**289 668**

Table 6

As shown in the previous graphs, the concrete types used are primarily C30/37 and C35/45. A more detailed analysis of these quantities is therefore provided in the following table. The reference EPD is available in the Anex of this document.

A1-A3

C30/37 and C35/45	2023			2024		
	Average kg CO2/m3	CO2 (KgCO2e)	Quantity (m3)	Average kg CO2/m3	CO2 (KgCO2e)	Quantity (m3)
BESIX FR	248	1 362 224	5 499	237	5 870 748	24 749
BESIX Nederland BV	162	16 872 961	104 252	177	1 483 660	8 393
BESIX NV	205	3 992 162	19 501	201	8 296 776	41 270
SM BESIX - GALERE	218	100 681	462	-	-	-
TM COTU	251	32 883 261	131 056	246	33 345 980	135 812
TM ROCO	251	1 391 014	5 546	227	4 362 269	19 212
Grand Total	**213**	**56 602 303**	**266 316**	**233**	**53 359 433**	**229 436**

REFERENCE : EPD Fedbeton *issued 31/03/2021* of a typical Belgian Ready-mixed concrete class C30/37, environmental class EE2, consistency class S4, produced using CEM III/A 42,5 N LA and with a (standard) maximum grain size of 22 mm	**170 KgCO2e/m3**

Table 7

Other references :

Buildwise

Quickstart guide link

Materials	Unit	Comment	A1-A3 (production) kg CO2 eq GWP Fossil	A1-A3 (production) kg CO2 eq GWP Biogenic	A4 (Transport to construction site) kg CO2 eq GWP Fossil	A5 (Construction and installation) kg CO2 eq GWP Fossil	C1 (Demolition, deconstruction) kg CO2 eq GWP Fossil	C2 (Waste transport) kg CO2 eq GWP Fossil	C3 (Waste treatment) kg CO2 eq GWP Fossil	C3 (Waste treatment) kg CO2 eq GWP Biogenic	C4 (Waste elimination) kg CO2 eq GWP Fossil	C4 (Waste elimination) kg CO2 eq GWP Biogenic
Concrete cast in situ (C30/37, EE3, CEM IIA)	m^3	360 kg cement/m^3 concrete	319.56	-	16.06	26.35	10.07	14.47	3.06	-	0.72	-
Concrete cast in situ (C30/37, EE3, CEM IIB)	m^3	360 kg cement/m^3 concrete	272.89	-	16.06	24.02	10.07	14.47	3.06	-	0.72	-
Concrete cast in situ (C30/37, EE3, CEM IIIA)	m^3	360 kg cement/m^3 concrete	228.88	-	16.06	21.82	10.07	14.47	3.06	-	0.72	-
Concrete cast in situ (C30/37, EE3, CEM IIIB)	m^3	360 kg cement/m^3 concrete	170.47	-	16.06	18.90	10.07	14.47	3.06	-	0.72	-
Concrete cast in situ (C30/37, EE3, CEM V/A)	m^3	360 kg cement/m^3 concrete	221.53	-	16.06	21.45	10.07	14.47	3.06	-	0.72	-
Concrete cast in situ (C35/45, EE4, CEM I)	m^3	390 kg cement/m^3 concrete	371.09	-	16.06	28.93	10.07	14.47	3.06	-	0.72	-
Concrete cast in situ (C35/45, EE4, CEM IIA)	m^3	390 kg cement/m^3 concrete	344.47	-	16.06	27.60	10.07	14.47	3.06	-	0.72	-
Concrete cast in situ (C35/45, EE4, CEM IIB)	m^3	390 kg cement/m^3 concrete	293.91	-	16.06	25.07	10.07	14.47	3.06	-	0.72	-
Concrete cast in situ (C35/45, EE4, CEM IIIA)	m^3	390 kg cement/m^3 concrete	246.23	-	16.06	22.69	10.07	14.47	3.06	-	0.72	-
Concrete cast in situ (C35/45, EE4, CEM IIIB)	m^3	390 kg cement/m^3 concrete	182.96	-	16.06	19.52	10.07	14.47	3.06	-	0.72	-
Concrete cast in situ (C35/45, EE4, CEM VA)	m^3	390 kg cement/m^3 concrete	238.26	-	16.06	22.29	10.07	14.47	3.06	-	0.72	-

Table 8

Finally, this table summarizes the values for high-performance concrete. Since the cement content in this type of mix is significantly higher, the carbon footprint is also considerably greater.

A1-A3						
	2023			2024		
High perfomance	Average kg CO2/m3	CO2 (KgCO2e)	Quantity (m3)	Average kg CO2/m3	CO2 (KgCO2e)	Quantity (m3)
BESIX FR	353	4 809 372	13 632	420	13 021 308	30 980
BESIX Nederland BV	199	3 605 482	18 133	215	2 527 432	11 777
BESIX NV	238	27 277	115	238	436 500	1 832
TM ROCO	-	-	-	259	317 622	1 227
Grand Total	**265**	**8 442 130**	**31 880**	**356**	**16 302 861**	**45 816**

Table 9

3.2 Transport: A4

As the distance between the ready-mix batching plant to the project sites is project specific an average distance of 25 km has been considered. Calculation of the transport related emissions are calculated based on weight multiplied with an emission factor of 0,256 kg CO2/tonkilometer (www.CO2emissiefactoren.nl – vrachtwagen 10 tot 20 ton bulkgoederen)

The EPD Fedbeton typical Belgian ready-mixed concrete C30/37 mentions a value of 6,72 kg CO_{2eq}/m^3 of ready-mix concrete considering a transport distance of 17km. We think a distance of 25km is more realistic.

For the weight an average of 2.370kg per m3 has been used (value coming from EPD Fedbeton typical Belgian ready-mixed concrete C30/37).

This means that per m^3 of ready-mix concrete the emissions related to transport from batching plant to the construction site : 2,37 ton / m3 * 0,256 kg/tonkm * 25km = 15,17 kg CO_{2eq}/m^3 of ready-mix concrete.

Our computed value is close to the reference value of Buildwise showed in Table 10.

3.3 Construction process stage : A5

After transport to site, the ready-mixed concrete mixtures needs to be processed on the construction site. Just as stages A4 (transport) is stage A5 (construction) specific to each project.

During the processing of ready-mix concrete on site , the following equipment is normally used:

- Concrete pump or a tower/mobile crane for transporting the concrete bucket, which is filled by the concrete mixer, to the processing location. For large pours a concrete pump is used while for smaller pours such as columns this is done by a tower crane and concrete bucket.
- Vibrating needle to compact the ready-mix concrete. This type of equipment is powered through a connection to the site electric grid which is connected with the grid. On infrastructure projects it is possible that electricity is produced by using power generators.

On-site energy consumed by the above mentioned equipment also has a footprint that needs to be monitored. To obtain data for these LCA stages, on-site monitoring is necessary but complex. However, an estimate of 11,1 kg $CO2_{eq}$ per m^3 of ready concrete is used based on the A5 data from the Fedbeton EPD of a typical Belgian Ready-mixed concrete class C30/37.

As for the Buildwise value, it is higher, ranging between 18 and 30 $kgCO_2e/m^3$.

A second point during construction is the production of waste, which also needs to be monitored in order to better control and limit the quantity of waste. As this is expected to be minimal, this is not taken into account in the value chain analysis.

3.4 Use stage : B

Maintenance activities may require additional concrete or materials, contributing to resource use and potential environmental impacts associated with material extraction and production. Using durable and long-lasting concrete mixes can reduce the frequency of maintenance and the need for additional materials. But the B phase is often very insignificant compared to the carbon footprint of materials production. The GWP of this phase is therefore accounted as zero.

3.5 End-of-life : C

At the end-of life, concrete structures undergo a demolition process facilitated by machinery such as cranes and crushers. The environmental repercussions of this process are contingent upon the quantity and composition of structures, as well as the specific machinery employed. Following demolition, the residual materials include concrete granulate and old rebar, both of which are potential candidates for recycling.

Concrete granulate, once extracted, can be repurposed as a substitute for traditional gravel in foundation material. Simultaneously, the rebar can undergo recycling processes to be transformed into fresh steel, promoting the circular economy.

The recovered concrete is transported to recycling facilities where it is crushed into smaller pieces. Advanced technologies can separate and purify the cement paste from the aggregates, making it possible to produce high-quality recycled materials. The recycled aggregates are then supplied to ready-mix concrete plants. These plants can use the recycled materials to produce new concrete, reducing the need for virgin aggregates and lowering the environmental impact.

According to the EPD Fedbeton **25,75 kg $CO2_{eq}$ per m^3** can be used for calculating the C-LCA phase. This value is the sum of:

- C1 deconstruction / demolition = 9,21 kg CO_{2eq} per m^3
- C2 transport after demolition = 12,5 kg CO_{2eq} per m^3
- C3 waste processing after demolition = 3,3 kg CO_{2eq} per m^3
- C4 disposal = 0,744 kg CO_{2eq} per m^3

All the values listed above are similar to the one of Buildwise presented in Table 10.

3.6 Benefits and loads beyond the system boundary : D

At the end of its life, concrete can go in many different directions. One possibility is to reuse it as aggregates for roads. A second possibility is to recycle aggregates in concrete, although this method is still limited and only 30% of recycled aggregates are used.

Reuse as such is still very uncommon on the market, due to the complexity of this method for concrete elements such as beams. Dismantling is complex because it requires a mechanical assembly rather than a chemical one. We don't know the internal reinforcement, etc. Some elements are easier to reuse such as hollow prefab slab, which are constant.

As per Fedbeton EPD a negative value of -8, 26 kg CO_{2eq} per m^3 can be considered.

3.7 Total amount of emissions in the value chain

The table below summarizes the emissions per life cycle and consolidated over all LCA phases for 2023 and 2024, for a concrete strength of C30/37 or C35/45 (including the project TM COTU and TM ROCO):

Phase	2023 emissions in kg CO_{2eq} per m^3	%	2024 emissions in kg CO_{2eq} per m^3	%
A1-A3 - Production incl. raw materials	212.5	80.34%	232.6	81.72%
A4 - Transport (upstream)	15.17	5.73%	15.17	5.33%
A5 - Processing on site	11.1	4.20%	11.1	3.90%
C - Demolition & disposal	25.75	9.73%	25.75	9.05%
Total emissions per m^3 ready-mix concrete	265		285	

Table 10

4. Reduction measures

As outlined in chapter 3.7, the highest potential for reducing the environmental footprint of ready-mix concrete lies in the extraction of raw materials and the production process, particularly in the selection of cement types used in concrete mixtures.

BESIX is committed to minimizing the environmental impact of ready-mix concrete through various measures, both already implemented and under development.

The following sections outline key areas of focus:

4.1 Sector initiatives

BESIX is conscious that transitioning the ready-mix concrete and cement sector to a more sustainable production process is something that BESIX can't do alone. Only by a collaborative approach between client, concrete manufacturers and contractors this ambition can be reached.

It is therefore that BESIX joined and/or is participating in a number of initiatives:

- In 2020, BESIX has committed in the Netherlands to the 'Betonakkoord' (2018 version) in which the following six objectives are formulated:
  - → at least 30% CO_2 reduction by 2030 compared to 1990, aiming for a reduction of 49%.
  - → 100% high-quality use of the released concrete (raw materials, elements, components), where there is transparency about the origin and composition of the reused concrete
  - → creating a net positive value of natural capital in the concrete sector
  - → promoting innovations and social capital
  - → cooperation in the concrete chain for further sustainability
  - → consistent demand for sustainable concrete
- In Flanders (Belgium), BESIX and BESIX Infra were one of the initiative takers to launch a Flemisch concrete agreement similar to the one in the Netherlands. Both BESIX as BESIX Infra signed in 2022 the "Circulaire Betonakkoord" with the following ambitions :
  - → by 2030, we aim for a 50% reduction in CO_2-eq emissions from concrete applied in the Flemish Region (including extraction and reuse of raw materials, transport and construction/installation) compared to 1990 emissions.
  - → by 2050, we are working towards 0 kg CO_2-eq emissions per m^3 concrete applied in the Flemish Region.
  - → by 2030, all the concrete from demolition whose quality is suitable for producing high-quality aggregates will be reused in ready-mixed concrete, road concrete and/or precast concrete.
  - → by 2030, buildings and structures will be designed so that concrete elements can be maximally reused, or that the functional adaptability is allowed and the use of problematic substances that hinder high-quality recycling is avoided.
  - → by 2030, for every application of concrete, the most appropriate sustainable concrete mix should be used. Calculation rules and quality assurance should be adapted accordingly.

- Through the sustainability Steerco of ADEB-VBA BESIX is participating in the Belgian Alliance for Sustainable Construction. More specifically BESIX is active in the workgroup on scope 3 reduction in collaboration with Buildwise (knowledge institute).

4.2 Working with and sensitizing the Client / Customer

Beyond the role of ready-mix concrete manufacturers, as mentioned in chapter 2.1, the client's sustainability ambitions play a crucial role in shaping project outcomes.

Through early contractor involvement BESIX can influence the choices made by the client and/or by the client contracted engineering companies, not only in the design phase but also during construction. By discussing environmental performance criteria early in the tendering phase in all transparency, BESIX can guide clients toward lower-carbon solutions and influence material selection, mix designs, and construction methodologies. A choice for CEM III can for example have a negative influence on the planning. It is then up to the Client to make choices.

BESIX actively engage with (possible) clients to discuss upfront decarbonization strategies. A detailed PPT has been developed within BESIX and serves as guideline during meetings with (possible) clients.

By setting up (sector) initiatives and/or development projects in cooperation with (regional) authorities / private clients, BESIX can stimulate the transition to a more sustainable construction sector.

4.3 Design optimization

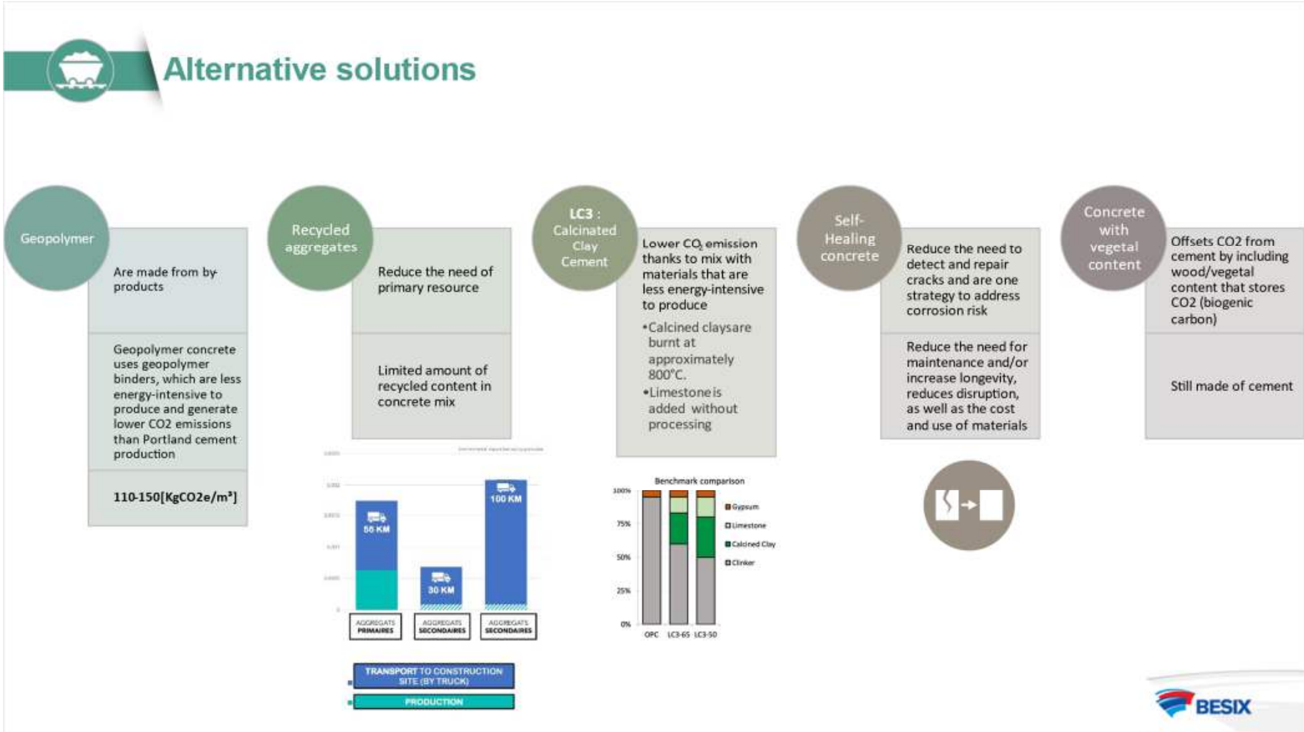
BESIX Engineering Department applies value engineering to optimize structural designs, focusing on reducing material quantities without compromising performance. This ensures cost efficiency and resource efficiency in every project and therefore helps to decrease the carbon footprint. This approach is supported by a dedicated sustainability team specializing in life cycle assessment (LCA). By conducting project-specific analyses, they pinpoint carbon hotspots and determine the most impactful CO_2 reduction strategies.

For concrete-related optimizations, BESIX relies on its in-house concrete experts, who closely follow the latest industry developments and integrate the most sustainable solutions available. These specialists work proactively to ensure that low-carbon alternatives are considered as soon as they become viable for project implementation.

BESIX combines the expertise of its engineering, sustainability, and concrete teams to apply the most feasible and effective low-carbon solution for each project.

4.4 Use of CEM III and alternatives

Over the past decade, the concrete industry has transitioned from traditional CEM I (Portland cement) to CEM III (blast furnace slag cement), significantly reducing emissions. However, with the steel industry shifting towards electric arc furnace (EAF) technology, the availability of blast furnace slag will decrease. This makes the transition to alternative cementitious materials essential. We are following new developments such as : Geopolymer, LC3 – Calcinated clay cement, Concrete with vegetal content, Self-healing concrete,...



There are already well-known cement types, CEMII and CEMIII, where the amount of Portland clinker is reduced by replacing it with secondary raw materials from other industrial processes. A replacement of Portland clinker with blast-furnace cement of up to 65% can be achieved in a CEM III/A mixture whereby the CO2 produced and the high-temperature needs are tackled. In a CEM III/B one goes up to a maximum ratio of blast furnace slag/ Portland cement clinker of 80/20 where with a CEM III/A this is a maximum ratio is 65/35. By applying a CEM III/C with a maximum ratio of blast furnace slag/ Portland cement clinker of 95/5, an even greater reduction is possible. By switching completely from 100% CEM III/A (437 kg CO2/ton) cement to 100% CEM III/B (325 kg CO2/kg) cement, a 26% reduction can be achieved.

Within BESIX Group, CEM III/A is mainly used in the buildings sector while in the infrastructure sector more use is already made of CEM III/B (specifically in the Netherlands). Based on the volumes purchased from BESIX Group, the replacement of CEM III/A to CEM III/B could lead to an estimated reduction of 22,500 tons of CO2. However, one should always take into account the concrete standards, which clearly indicate which cement type should be used according to the strength and environment categories.

The replacement of Portland clinker in fact affects strength formation and durability performance in certain environments. This also applies to a concrete type with total cement replacement. Consequently, due to arguments raised above, CO2 reduction is not always possible and the project team to investigate the possibilities on a project-specific basis.

4.5 Recycled aggregates

BESIX is exploring the increased use of recycled aggregates sourced from demolition waste and secondary raw materials.

High-quality reuse of recycled concrete aggregates (RCA) provides an answer offered to the irresponsible mining of non-renewable raw materials, which are already or will soon show scarcity. By focusing on a circular approach on the concrete already contained in our infrastructure and buildings, not only does it address the mining of primary raw materials, but also saves on the CO2 emitting production process. This approach requires a well-coordinated process from demolition to the pouring of concrete. Indeed, demolition has to be done selectively to obtain pure concrete rubble. The larger concrete chunks are then broken in several cycles and tumbled into aggregates corresponding to the shape and dimensions specified in the concrete standard. During mixing the new concrete mix, sufficient attention should be paid to the proper water management, as RCA often attracts more water, leaving less to react with cement. This water-attracting property of RCA comes from the remaining cement still contained in the RCA, which in turn wants to react with water. The use of RCA can affect the strength development and durability performance of concrete.

If BESIX needs to carry out its own demolition work, it will examine with its chain partners whether it can reuse the released demolition waste in the production process. BESIX and in particular BESIX Infra have the ambition to respond strongly to this. In addition, alternative fillers can be used such as residual products derived from the production of stainless steel or residues from the thermal cleaning of tar asphalt, some of which can also absorb CO2.

Regarding recycled aggregates, some studies have shown that transportation has a significant impact. As illustrated in the graph below, recycled aggregates are only beneficial in terms of carbon footprint if they are sourced locally.

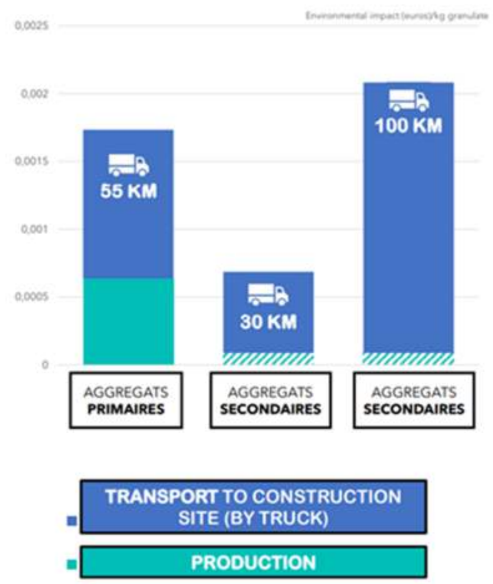


Figure 13

4.6 Transport

Transporting concrete involves the use of vehicles, leading to energy consumption and emissions. The type of fuel used in transportation significantly influences the environmental impact. Optimizing transport routes and using fuel-efficient vehicles can help to reduce the energy consumption and related emissions. Moreover, transitioning to alternative fuels, such as HVO or shifting to electric or hybrid vehicles, can mitigate the impact of concrete transport. During contract negotiation with the ready-mixed concrete supplier, a dialogue to opt for more sustainable transport (use of HVO, electrification, hydrogen,...) can be held.

For larger projects a feasibility study will be made for the use of on-site batching plants. This becomes even more interesting when the project is situated near water ways. Additionally if the project is spread over a long distance opting for two batching plants, each covering a part of the project, can reduce the amount of transport.

Finally, planning large pours outside rush hour has a direct impact on the emissions.

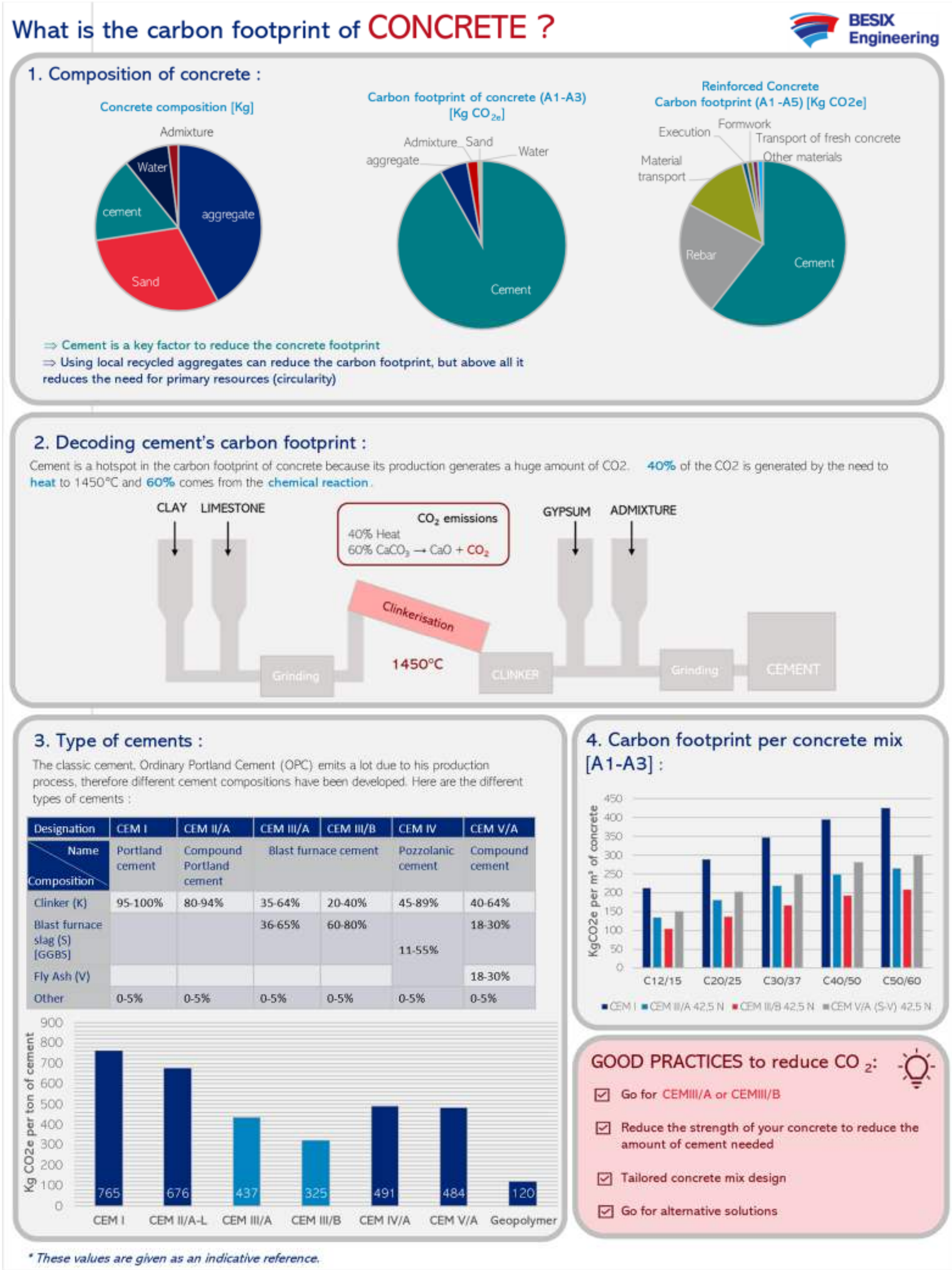
BESIX is aware that transportation also has a significant impact. One potential reduction measure would be to gain a better understanding of the transport chain. Therefore, a value chain analysis of transportation would be highly relevant.

4.7 Collaboration and supply chain engagement

Collaboration with the ready-mixed concrete suppliers is key! The Procurement and Engineering Departments of BESIX actively engages with suppliers through dedicated workshops, including the Supplier Sustainability Forum and low-carbon product presentation meetings. These initiatives foster collaboration, promote sustainable innovations, and encourage the adoption of lower-carbon materials across the supply chain.

4.8 Internal training

One of the key factors in reducing our carbon footprint is ensuring that everyone joins the transition. To make sure no one is left behind, we prioritize communication and knowledge-sharing through training sessions (such as BDA,...) and newsletters, as illustrated in the image below.



Designation	CEM I	CEM II/A	CEM III/A	CEM III/B	CEM IV	CEM V/A
Name / Composition	Portland cement	Compound Portland cement	Blast furnace cement		Pozzolanic cement	Compound cement
Clinker (K)	95-100%	80-94%	35-64%	20-40%	45-89%	40-64%
Blast furnace slag (S) [GGBS]			36-65%	60-80%	11-55%	18-30%
Fly Ash (V)						18-30%
Other	0-5%	0-5%	0-5%	0-5%	0-5%	0-5%

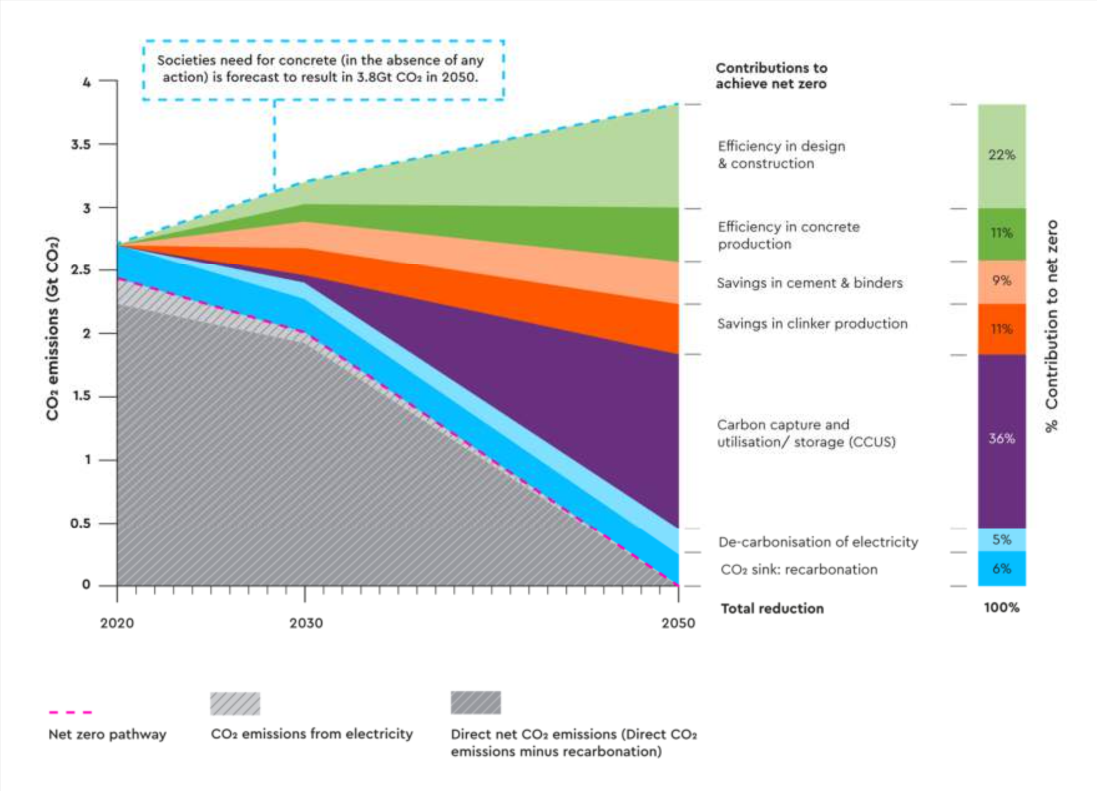
4.9 Research & development

BESIX has a highly qualified internal engineering department with multiple concrete specialists. By participating in master thesis and research & development projects in collaboration with the Academic world BESIX actively supports the search to sustainable alternatives for the current ready-mixed concrete mixtures.

Through BESIX Technology BESIX Group continuously monitors the market evolution with the objective to support and invest in start-ups. At the same time, BESIX acts as an industrial partner for testing new and innovative products and materials.

5. Ambition and targets

The Global Cement & Concrete Association (GCCA) has defined a roadmap to net-zero for their sector indicating the levers that must be implemented to reduce CO_2 emissions at the different stages of the whole life of cement and concrete. The roadmap process has evaluated the role that each of these levers will play to reach net zero. The global average is presented in the graph below. Across the world each lever will be implemented in accordance with local factors.



Source : Getting to Net Zero (gccassociation.org)

The sector in Belgium and the Netherlands, and derived sector initiatives such as the ‘Betonakkoord Nederland’ and ‘Circulair Beton Vlaanderen’, targets a reduction of at least 30% by 2030 compared to 1990. As a signatory of both agreements, BESIX has defined annual reduction targets up to 2030 in line with these agreements.

Based on the study 'Klimaatimpact van betongebruik in de Nederlandse bouw - vergelijking 1990, 2020 en 2017' dd. September 2020 performed by CE Delft the 1990 vale for ready-mix concrete has been determined. Annual sub-targets have been defined relative to the 1990 reference value and taking into account the Betonakkoord CO2 roadmap version 1.2 dd. 20/01/2021, the reduction roadmap of the cement branch organization Febelcem and cement supplier information indicating that the largest reduction is expected from 2028 onwards once the planned carbon capture projects are operational.

The possible shortage of fly ash and blast furnace slag in the coming years due to the shift in the steel manufacturing industry from BOF to EAF which will lead to an increase of the average emissions per ton of cement has not been taken into account in the target setting. This will be evaluated yearly and if required target setting will be adapted

As BESIX is not a ready-mixed concrete supplier itself and that often concrete strength and mixtures are prescribed in the technical specification, BESIX focuses on four areas:

- Reduction at the source through:
    - awareness creation amongst private and public clients and going in dialogue with them on applying design alternatives/optimizations and more sustainable materials which means often to allow the General Contractors to opt for innovation by less prescribing strict technical requirements during tender phase. BESIX continues to invest in workshops and dialogue sessions with clients to increase awareness and create partnerships.
    - optimizing the design (reducing dimensions, optimization of mix design) where possible (this is one of the area's in which BESIX distinguishes itself from its competitors). We are promoting CEMIII and trying to reduce the strength class in order to reduce the quantity of cement needed.
    - partnerships with ready-mixed concrete suppliers to engage and encourage collaboration towards innovative and more sustainable solutions. BESIX continues to go in dialogue with these suppliers during visits, workshops, supplier forums,...
    - going in dialogue with standardization bodies for reviewing current standards which is holding back innovation today (for example increasing the % of allowed recycled aggregates). To be successful this will be taken up at sector level.
- stimulating innovation and research & development through:
    - collaborating with the academic world as an industrial partner in master theses
    - searching for alternative and more sustainable solutions through research & development, market screening and monitoring of innovations and start-ups. BESIX Group has created a dedicated department, BESIX Technology, to facilitate innovation and supporting start-ups.
- reducing the emission during the application of ready-mixed concrete on site by going in dialogue with ready-mixed concrete suppliers on their production process, transportation methods to the site and data availability.
- internal & external awareness creation through:
    - newsletter, posters and training
    - creating a knowledge of alternative or low carbon solutions (geopolymer, LC3 – Calcinated clay cement, concrete with vegetal content, self-healing concrete,...

As mentioned above BESIX has defined annual reduction targets related to the 1990 value. In order to track progress a detailed analysis was initiated in 2022 which was further completed in 2023 on the amount and type of ready-mix concrete applied by BESIX in order to define an average carbon emission per m3 for this type of product. This average value is calculated for the life cycle phase A1 to A3 and serve as a baseline for monitoring progress in reducing carbon emissions for this type of material. As from 2024 this is now monitored on a 6-monthly basis.

As presented in this document, the most commonly used strength classes are C30/37 and C35/45. A specific KPI has been defined for these classes. It is logical to distinguish between high-performance concrete and more standard concrete, as their CO_2 values vary significantly. To ensure a like-for-like comparison, the following KPI and monitoring focus specifically on C30/37 and C35/45. High-performance concrete is also monitored, but considered separately. Other strength classes are measured as well, though they are used in much smaller quantities.

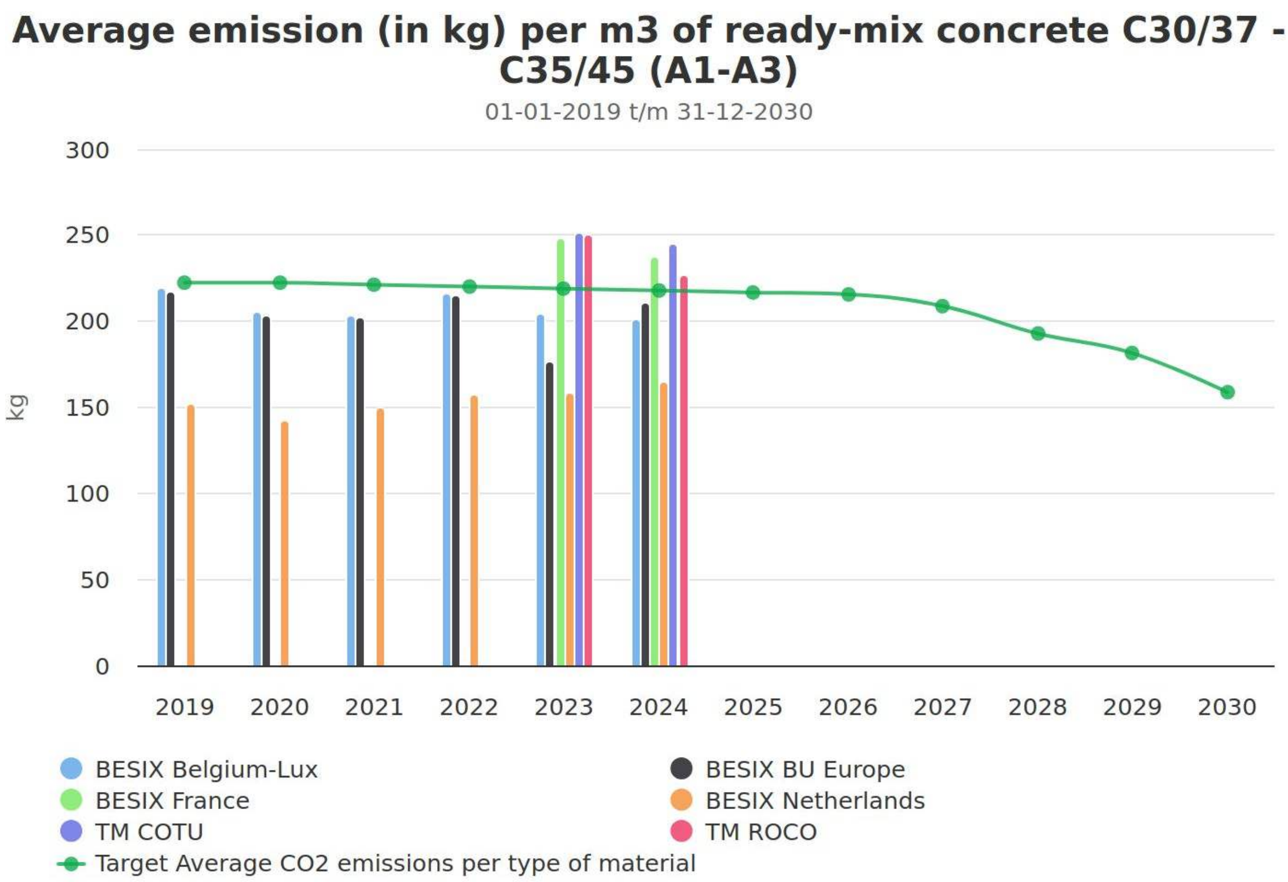

Average emission (in kg) per m3 of ready-mix concrete C30/37 - C35/45 (A1-A3)
01-01-2019 t/m 31-12-2030
300
250
200
150
100
50
0
kg
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
BESIX Belgium-Lux
BESIX BU Europe
BESIX France
BESIX Netherlands
TM COTU
TM ROCO
Target Average CO2 emissions per type of material

Figure 14

6. References

- → EPD Fedbeton issued 31/03/2021 of a typical Belgian Ready-mixed concrete class C30/37, environmental class EE2, consistency class S4, produced using CEM III/A 42,5 N LA and with a (standard) maximum grain size of 22 mm
- → Betonakkoord Nederland
- → Circulair Betonakkoord Vlaanderen
- → Net-zero roadmap GCCA
- → Net-zero roadmap Febelcem
- → 'Klimaatimpact van betongebruik in de Nederlandse bouw - vergelijking 1990, 2020 en 2017' dd. September 2020 performed by CE Delft

7.2 EPD FED Beton – C30/37

B-EPD ENVIRONMENTAL PRODUCT DECLARATION

FEDBETON
TYPICAL BELGIAN READY-MIXED CONCRETE

1 m³ of ready-mixed concrete of strength class C30/37, environmental class EE2, consistency-class S4, produced using cement CEM III/A 42,5 N LA and with a (standard) maximum grain size of 22mm, used in various construction works with a reference service life of 100 years

Issued 31.03.2021
Valid until 31.03.2026

Third party verified
Conform to EN 15804+A2 and NBN/DTD B08-001
EN16757:2017 and ISO 14025

Cradle to gate with options

Modules declared					
A123	A4	A5	B2 B4 B6	C	D
•	•	•	•	•	•

[B-EPD n° 21-0069-002-00-01-EN]

FEDBETON THINK CONCRETE

OWNER OF THIS ENVIRONMENTAL PRODUCT DECLARATION
FEDBETON vzw

EPD PROGRAM OPERATOR
Federal Public Service of Health, Food Chain Safety and Environment
www.b-epd.be

The intended use of this EPD is to communicate scientifically based environmental information for construction products, for the purpose of assessing the environmental performance of buildings. This EPD is only valid when registered on www.b-epd.be. The FPS Public Health cannot be held responsible for the information provided by the owner of the EPD.

2

PRODUCT DESCRIPTION

PRODUCT NAME

C30/37-EE2-BA-Dmax 20mm-CEM III/A 42,5 N LA (Typical Belgian ready-mixed concrete)

PRODUCT DESCRIPTION AND INTENDED USE

Ready-mixed concrete is made by weighing and mixing sand, gravel, cement, water and most of the time admixtures. Ready-mixed concrete is produced in a fixed plant and transported with truck mixers to the jobsite right before installation. Here it is poured in formwork and compacted. The surface is finally finished by professionals. Once the concrete is hardened enough, the formwork is removed.
The specific type of concrete this document refers to is widely used in common applications: beams, columns, walls, foundations, slabs, etc., and can be used in various dimensions. For floorings (limited thickness) formwork is only applied at the borders. In structural concrete steel reinforcement is placed in the formwork before the actual pouring of the concrete. This EPD only takes the concrete without reinforcement into consideration and does not consider the formwork as it is re-used many times.

The concrete can be used in dry or wet conditions (environmental class EE2). The strength class is C30/37. The used cement is CEM III/A 42,5 N LA. The fluidity is high (consistency class S4).

The variability within the product group has been investigated using the guidelines of the B-PCR (NBN/DTD B 08-001:2017). The variability assessment revealed that the results present in this EPD are valid for all members of FEDBETON and all their production sites.

REFERENCE FLOW / DECLARED UNIT

The declared unit consists of 1 m^3 of ready-mixed concrete of strength class C30/37, environmental class EE2, consistency-class S4, produced using cement CEM III/A 42,5 N LA and with a (standard) maximum grain size of 22mm, used in various construction works with a reference service life of 100 years.

Packaging is not relevant for ready-mixed concrete.
Pumping and installation are included.
Ancillary materials for installation (formwork) are not included as they are re-used many times.

The weight per reference flow is 2370 kg.

INSTALLATION

The ready-mixed concrete is transported with truck mixers to the jobsite for installation. The concrete is pumped into the formwork and compacted. The impact of the pump, compaction and the concrete mixer of the truck are included. The formwork itself is not included in this study as it is re-used many times.

IMAGES OF THE PRODUCT AND ITS INSTALLATION

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Composition and content

Ready-mixed concrete is transported with truck mixers to the jobsite right before installation, no packaging material is needed. The main components of the product are:

Components	Composition / content / ingredients	Quantity (Mass fraction)
Product	Cement	13%
	Sand	35%
	Gravel	44%
	Water	7%
	Admixture	<1%

The product does not contain materials listed in the "Candidate list of Substances of Very High Concern for authorization".

Reference service life

The reference service life is 100 years. This RSL is marked as a common lifetime for concrete products in the PCR for concrete and concrete elements (NBN EN16757:2017). This RSL is valid for ready-mixed concrete of environmental class EE2 (outdoor applications which may be in contact with frost, but not with rain), as considered in this EPD. 4

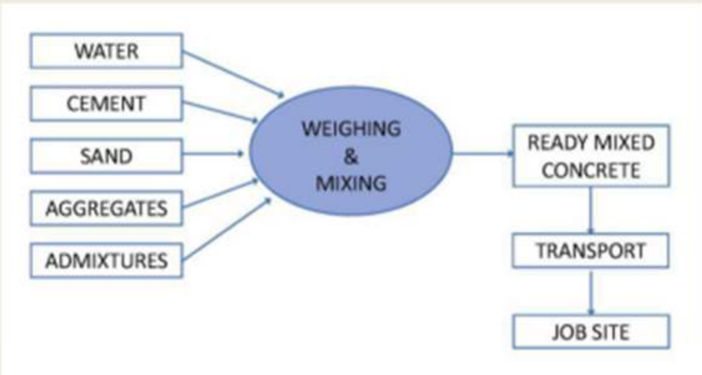
No specific maintenance is required to the concrete. No replacements are necessary over the lifetime of a building.

Description of geographical representativity

The EPD is representative for the Belgian market.
The composed datasets for this life cycle assessment are representative and relevant for ready-mixed concrete produced by the members of FEDBETON in Belgium.

Description of the production process and technology

The required amount of raw materials (aggregates, sand, cement, water and admixtures) are carefully weighed. These materials are then mixed until a homogeneous fluid concrete is obtained. This mixture is brought into the truck mixer and transported to the construction site, where it is processed. The concrete can be poured directly into the formwork or with the help of a crane or concrete pump.



4

TECHNICAL DATA / PHYSICAL CHARACTERISTICS

Technical property	Standard	Value	Unit	Comment
Compressive strength (at 28d, measured on cubes)	EN 12390-3	45	MPa	Average value
Thermal conductivity	EN 12667	1,3	W/mK	in dry conditions - not reinforced
Bending tensile strength	EN 12390-5	6,3	MPa	Approximate value
E-modulus	EN 12390-13	33.000	MPa	Approximate value
Specific weight	EN 12390-7	2370	kg/m3	Average value

LCA STUDY

DATE OF LCA STUDY

March 2021

SOFTWARE

For the calculation of the LCA results, the software program SimaPro 9.1.1.1 (PRé Consultants, 2021) has been used.

INFORMATION ON ALLOCATION

The production of ready-mixed concrete consists of weighing and mixing the components (aggregates, cement, water, admixtures). Different types of concrete are essentially distinguished by the nature of the raw materials used and the quantity that is dosed from each raw material. The weighing and mixing of the various concrete types takes place in a similar way and has no significant impact on energy consumption and emissions. It can therefore be said that the total energy consumption of a concrete plant on an annual basis compared to the total amount of concrete produced in the same period is an average that can be used for all concrete types. The data per plant is allocated to the specific product using the annual production weight of the product (physical relationship).

INFORMATION ON CUT OFF

The following processes are considered below cut-off: losses during transport are considered to be below cut-off because ready-mixed concrete is transported in a closed truck and cannot break or fall off the truck; environmental impacts caused by the personnel of the production plants are not included in the LCA, e.g. waste from the cafeteria and sanitary installations, accidental pollution caused by human mistakes, or environmental effects caused by commuter traffic. Heating or cooling of the plants in order to ensure a comfortable indoor climate for the personnel for example is also neglected. The total of neglected input flows is less than 5% of energy usage and mass as prescribed by EN15804+A2.

INFORMATION ON EXCLUDED PROCESSES

Only the processes considered below cut-off are excluded from the study. No additional processes are excluded.

INFORMATION ON BIOGENIC CARBON MODELLING

The product does not contain biogenic carbon.

INFORMATION ON CARBON OFFSETTING

Carbon offsetting is not allowed in the EN 15804 and hence not taken into account in the calculations.

INFORMATION ON CARBONATION OF CEMENTITIOUS MATERIALS

Carbonation takes place during the use phase of ready-mixed concrete.[1] The impact of CO_2 removals from carbonation are calculated for different indoor and outdoor applications using the formulas provided in the PCR for concrete and concrete elements (EN16757:2017). $GWP_{carbonation}$ is calculated per m² surface of concrete. The concrete considered in this EPD can be used for many different applications with different dimensions, so the carbonation is not scaled to the functional unit of this EPD (1 m³). The calculation of $GWP_{carbonation}$ is based on the following assumptions: 47% clinker in the cement, 65% reactive CaO, service life of 100 years, 320 kg cement/m³ concrete, average compressive strength of 45 MPa.

Application	$GWP_{carbonation}$ per m² concrete surface	Unit
Outdoor - exposed to rain	0,718	kg CO_2 equiv.
Outdoor - sheltered from rain	1,555	kg CO_2 equiv.
Indoor - with cover	0,830	kg CO_2 equiv.
Indoor - without cover	1,168	kg CO_2 equiv.
In ground	0,326	kg CO_2 equiv.

ADDITIONAL OR DEVIATING CHARACTERISATION FACTORS

The characterization factors from EC-JRC were applied conform EN15804+A2. No additional or deviating characterization factors were used.

[1] The carbonation that takes place in module B1 is not included in the GWP-fossil indicator in the table "Potential environmental impacts per reference flow" because it's not clear where the CO_2-release of the carbonation will take place. The uptake and release of CO_2 coming from carbonation are both not considered in the GWP-fossil indicator.

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DESCRIPTION OF THE VARIABILITY

The variability within the product group has been investigated using the guidelines of the B-PCR (NBN/DTD B 08-001:2017). The EPD will be a sector EPD for typical Belgian ready-mixed concrete, from different manufacturers and plants. It's investigated if all the manufacturers covered in one representative EPD is reasonable for the product group represented.

The results of the variability study are in line with theguidelines of the B-PCR (NBN/DTD B 08-001:2017). Therefore, the results of the reference case are considered representative for all considered manufacturers and plants.

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DATA

SPECIFICITY

The data used for the LCA are representative for the production of typical Belgian ready-mixed concrete, manufactured by any of the 55 members of FEDBETON in Belgium in any of the 123 concrete plants. The variability within the product group has been investigated using the guidelines of the B-PCR (NBN/DTD B 08-001:2017).

PERIOD OF DATA COLLECTION

Manufacturer specific data have been collected for the year 2018.

INFORMATION ON DATA COLLECTION

Company specific data for the product stage have been collected from its members by FEDBETON and were provided to VITO through an online data collection questionnaire. The LCI data for the product stage have been checked by the EPD verifier (Vinçotte). VITO uses publicly available generic data for all background processes such as the production of electricity, transportation by means of a specific truck, etc.

DATABASE USED FOR BACKGROUND DATA

The main LCI source used in this study is the Ecoinvent 3.6 database (Wernet et al., 2016).

ENERGY MIX

The Belgian electricity mix (consumption mix + import) has been used to model electricity use in life cycle stages A3, A5, C1 and C4. The used record is the Ecoinvent record 'Electricity, low voltage {BE}| market for | Cut-off, U' (Wernet et al., 2016).

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Production sites

This EPD represents the production of ready-mixed concrete by the members of FEDBETON with following production sites:

APK Casters Beton - Genk	Devamix - Harelbeke	Inter-Beton - Roux
AC Materials - Brugge	Eloy Béton - Sprimont	Inter-Beton - Sint-Pieters-Leeuw
AC Materials - Puurs	Eloy Béton - Grace-Hollogne	Inter-Beton - Temse
AC Materials - Vlierzele	Envemat - Goé	Inter-Beton - Tessenderlo
AC Materials - Wondelgem	Envemat - St Vith	Inter-Beton - Tienen
AC Materials - Heist-op-den-Berg	Envemat - Verviers	Inter-Beton - Villers le Bouillet
Adams Polendam - Beerse	Famenne Béton - Heyd-Durbuy	Inter-Beton - Wellin
Adams Polendam - Geel	Famenne Béton - Marche-en-Famenne	Jacobs Beton - Sint-Katelijne-Waver
Adams Polendam - Massenhoven	Germain Vinckier - Diksmuide	Kerkstoel Beton - Grobbendonk
Ardenne Beton - Libramont-Chevigny	GNB Beton - Bastogne	Lambert Frères - Bastogne
BBE - Béton Bassin de l'Escaut	GNB Beton - Fernelmont	Mermans Beton - Arendonk
Béton Baguette - Thimister Clermont	GNB Beton - Stockem	Multi-Mix - Wondelgem
Bétons Feidt Belgium - Arlon	Goffette et Fils - Jamoigne	NB BETON - Eupen
Bétons Feidt Belgium - Bastogne	Goijens Betoncentrale - Bree	NB BETON - Gouvy
Betoncentrale Blomme - Nieuwpoort	H. Keulen Beton - Lanaken	NB BETON - Malmedy
Betoncentrale De Brabandere - Veurne	Holcim België - Aarschot	NB BETON - Waimes
B-mix Beton - Tessenderlo	Holcim België - Merksem	OBBC - Oosterzele
Bosschaert - Kortrijk	Holcim België - Overijse	OBC Ottevaere - Oudenaarde
Bouffioux - Longchamps	Holcim België - Sint-Truiden	Olivier Construct - Izegem 1
Buysse Beton - Evergem	Holcim Belgique - Bruxelles	Olivier Construct - Izegem 2
CCB - Baudour	Holcim Belgique - Dampremy	Paesen Betonfabriek - Houthalen
CCB - Bruxelles	Holcim Belgique - Gembloux	Ready Beton - Anderlecht
CCB - Couillet	Holcim Belgique - Ghlin	Ready Beton - Bruxelles
CCB - Gaurain-Ramecroix	Inter-Beton - Achêne	Ready Beton - Rotselaar
CCB - Ghislenghien	Inter-Beton - Braine-le-Château	René Pirlot et Fils - Virelles
CCB - Mont-Saint-Guibert	Inter-Beton - Brugge	Roosens Bétons - Bois d'Haine
CCB - Roucourt	Inter-Beton - Bruxelles	Roosens Betorix - Hermalle s/ Argenteau
CCB - Voorde	Inter-Beton - Dendermonde	Seegers Beton - Dilsen
CCB - Wevelgem	Inter-Beton - Flémalle	Stortbeton Hollevoet Rik - Torhout
CMIX - Huy	Inter-Beton - Genk	Tanghe - Ichtegem
CMIX - Liège	Inter-Beton - Gent	Tournai-Béton - Tournai
Coopmans DC	Inter-Beton - Grimbergen	Trans-Beton - Gent
De Rycke François Beton - Stekene	Inter-Beton - Heist o/d Berg	Trans-Beton - Lokeren
De Rycke Gebroeders - Kieldrecht	Inter-Beton - Liège	Trans-Beton - Roeselare
De Rycke Gebroeders - Kallo	Inter-Beton - Lommel	Trans-Beton - Wingene
De Snerck Betontcentrale - Kruishoutem	Inter-Beton - Mechelen	Transportbeton - Boom
De Witte Beton en bouwmaterialen - Herdersem	Inter-Beton - Menen	Transportbeton De Beuckelaer - Schoten
Declercq Stortbeton - Deinze	Inter-Beton - Moeskroen	Van Akelyen Betoncentrale - Zele
Declercq Stortbeton - Harelbeke	Inter-Beton - Mont Saint-Guibert	Wijckmans Bouwmaterialen - Ham
Declercq Stortbeton - Tielt	Inter-Beton - Jambes	Willemen Infra NV - Gent
Declercq Stortbeton - Wielsbeke	Inter-Beton - Oostende	

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Degetec - Desselgem	Inter-Beton - Quenast

System boundaries

Product stage			Construction installation stage		Use stage							End of life stage					Beyond the system boundaries
Raw materials	Transport	Manufacturing	Transport	Construction installation stage	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal		Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4		D
☒	☒	☒	☒	☒	MND	☒	MND	☒	MND	☒	MND	☒	☒	☒	☒		☒

X = included in the EPD
MND = module not declared

Potential environmental impacts per reference flow

	Production			Construction process stage		Use stage							End-of-life stage					
	A1 Raw material	A2 Transport	A3 manufacturing	A4 Transport	A5 Installation	B1 Use	B2 Maintenance	B3 Repair	B4 Replacement	B5 Refurbishment	B6 Operational energy use	B7 Operational water use	C1 Deconstruction / demolition	C2 Transport	C3 Waste processing	C4 Disposal	D Reuse, recovery, recycling	Total excl module D
GWP total (kg CO2 equiv/FU)	1,46E+02	2,06E+01	1,56E+00	6,72E+00	1,11E+01	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	9,21E+00	1,25E+01	3,30E+00	7,44E-01	-5,26E+00	2,14E+02
GWP fossil (kg CO2 equiv/FU)	1,46E+02	2,06E+01	1,57E+00	6,72E+00	1,11E+01	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	9,20E+00	1,25E+01	3,29E+00	7,43E-01	-5,22E+00	2,13E+02
GWP biogenic (kg CO2 equiv/FU)	7,22E-02	1,10E-02	3,10E-03	2,74E-03	3,15E-03	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	1,73E-03	5,05E-03	1,26E-02	5,31E-04	-3,45E-02	1,13E-01
GWP luluc (kg CO2 equiv/FU)	5,06E-02	1,71E-02	1,41E-03	2,35E-03	2,69E-03	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	7,25E-04	4,36E-03	6,34E-03	4,22E-04	-6,90E-03	1,16E-01
ODP (kg CFC 11 equiv/FU)	1,14E-06	4,41E-06	3,30E-07	1,53E-06	1,55E-06	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	1,99E-06	2,53E-06	5,96E-07	2,75E-07	-1,22E-06	1,50E-05
AP (mol H+ equiv/FU)	4,42E-01	1,24E-01	1,21E-02	2,74E-02	5,26E-02	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	9,63E-02	5,09E-02	1,49E-02	6,33E-03	-7,07E-02	8,26E-01
EP - freshwater (kg P equiv/FU)	2,33E-04	1,94E-04	1,92E-05	5,27E-05	2,57E-05	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	3,35E-05	9,75E-05	1,29E-04	9,84E-06	-2,65E-04	7,97E-04
EP - marine (kg N equiv/FU)	1,23E-01	4,56E-02	4,90E-03	8,14E-03	1,91E-02	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	4,25E-02	1,51E-02	4,13E-03	2,17E-03	-1,91E-02	2,65E-01
EP - terrestrial (mol N equiv/FU)	1,47E+00	5,02E-01	5,50E-02	9,00E-02	2,12E-01	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	4,66E-01	1,67E-01	4,73E-02	2,40E-02	-2,62E-01	3,04E+00
POCP (kg Ethene equiv/FU)	4,97E-01	1,39E-01	1,45E-02	2,76E-02	6,03E-02	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	1,26E-01	5,11E-02	1,29E-02	6,92E-03	-6,10E-02	9,37E-01
ADP Elements (kg Sb equiv/FU)	2,51E-05	3,13E-05	2,45E-06	1,31E-05	3,09E-06	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	2,36E-06	2,43E-05	6,05E-06	7,49E-07	-6,52E-05	1,05E-04

ADP fossil fuels (MJ/FU)	7,51E+02	2,99E+02	3,56E+01	1,01E+02	1,32E+02	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	1,27E+02	1,88E+02	1,01E+02	2,15E+01	-1,29E+02	1,76E+03
WDP (m³ water eq deprived /FU)	2,21E+01	9,15E-01	2,35E-01	2,82E-01	5,74E-01	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	1,70E-01	5,23E-01	9,26E-01	8,00E-01	-2,27E+00	2,65E+01

GWP total = total Global Warming Potential (Climate Change); GWP-luluc = Global Warming Potential (Climate Change) land use and land use change; ODP = Ozone Depletion Potential; AP = Acidification Potential for Soil and Water; EP = Eutrophication Potential; POCP = Photochemical Ozone Creation; ADPE = Abiotic Depletion Potential – Elements; ADPF = Abiotic Depletion Potential – Fossil Fuels; WDP = water use (Water (user) deprivation potential, deprivation-weighted water consumption)

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RESOURCE USE

	Production			Construction process		Use stage							End-of-life stage					
	A1 Raw material	A2 Transport	A3 manufacturing	A4 Transport	A5 Installation	B1 Use	B2 Maintenance	B3 Repair	B4 Replacement	B5 Refurbishment	B6 Operational energy use	B7 Operational water use	C1 Deconstruction / demolition	C2 Transport	C3 Waste processing	C4 Disposal	D Reuse, recovery, recycling	Total excl module D
PERE (MJ/FU, net calorific value)	1,53E+02	5,09E+00	2,53E+00	1,40E+00	3,97E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	6,74E-01	2,60E+00	1,09E+01	5,59E-01	-3,14E+01	1,81E+02
PERM (MJ/FU, net calorific value)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT (MJ/FU, net calorific value)	1,53E+02	5,09E+00	2,53E+00	1,40E+00	3,97E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	6,74E-01	2,60E+00	1,09E+01	5,59E-01	-3,14E+01	1,81E+02
PENRE (MJ/FU, net calorific value)	7,59E+02	3,03E+02	3,65E+01	1,02E+02	1,31E+02	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	1,26E+02	1,59E+02	1,09E+02	2,19E+01	-1,41E+02	1,75E+03
PENRM (MJ/FU, net calorific value)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT (MJ/FU, net calorific value)	7,59E+02	3,03E+02	3,65E+01	1,02E+02	1,31E+02	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	1,26E+02	1,59E+02	1,09E+02	2,19E+01	-1,41E+02	1,75E+03
SM (kg/FU)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF (MJ/FU, net calorific value)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF (MJ/FU, net calorific value)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW (m^3 water eq/FU)	3,43E+00	3,62E-02	7,26E-03	1,00E-02	7,30E-02	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	4,99E-03	1,86E-02	3,51E-02	1,91E-02	-8,07E-01	3,63E+00

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Net use of fresh water

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WASTE CATEGORIES & OUTPUT FLOWS

	Production			Construction process stage		Use stage						
	A1 Raw material	A2 Transport	A3 manufacturing	A4 Transport	A5 Installation	B1 Use	B2 Maintenance	B3 Repair	B4 Replacement	B5 Refurbishment	B6 Operational energy use	B7 Operational water use
Hazardous waste disposed (kg/FU)	2,77E-04	7,82E-04	5,92E-05	2,65E-04	3,15E-04	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND
Non-hazardous waste disposed (kg/FU)	5,68E-01	1,06E+01	1,05E-01	4,54E+00	2,55E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND
Radioactive waste disposed (kg/FU)	2,29E-02	2,03E-03	3,04E-04	6,91E-04	1,30E-03	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND
Components for re-use (kg/FU)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND
Materials for recycling (kg/FU)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND
Materials for energy recovery (kg/FU)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND
Exported energy (MJ/FU)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND

	End-of-life stage					
	C1 Deconstruction/ demolition	C2 Transport	C3 Waste processing	C4 Disposal	D Reuse, recovery, recycling	Total excl module D
Hazardous waste disposed (kg/FU)	3,45E-04	4,92E-04	9,27E-05	2,96E-05	-5,21E-04	2,66E-03
Non-hazardous waste disposed (kg/FU)	1,53E-01	5,99E+00	2,17E-01	1,15E+02	-1,53E+00	1,44E+02
Radioactive waste disposed (kg/FU)	5,50E-04	1,25E-03	9,17E-04	1,54E-04	-9,46E-04	3,05E-02
Components for re-use (kg/FU)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Materials for recycling (kg/FU)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,19E+03	0,00E+00
Materials for energy recovery (kg/FU)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Exported energy (MJ/FU)	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00

IMPACT CATEGORIES ADDITIONAL TO EN 15804

	Production			Construction process		Use stage							End-of-life stage					
	A1 Raw material	A2 Transport	A3 manufacturing	A4 Transport	A5 Installation	B1 Use	B2 Maintenance	B3 Repair	B4 Replacement	B5 Refurbishment	B6 Operational energy use	B7 Operational water use	C1 Deconstruction / demolition	C2 Transport	C3 Waste processing	C4 Disposal	D Reuse, recovery, recycling	Total excl module D
PM (disease incidence)	3,56E-06	1,13E-06	2,93E-07	4,67E-07	7,53E-07	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	1,17E-05	5,67E-07	1,94E-07	1,21E-07	-1,25E-06	1,91E-05
IRHH (kg U235 eq/FU)	3,93E+00	1,32E+00	3,04E-01	4,43E-01	6,15E-01	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	5,43E-01	5,21E-01	1,05E+00	1,19E-01	-1,15E+00	9,15E+00
ETF (CTUe/FU)	4,36E+03	2,39E+02	1,87E+01	5,11E+01	1,54E+02	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	7,64E+01	1,50E+02	5,04E+01	1,32E+01	-1,59E+02	5,15E+03
HTCE (CTUh/FU)	3,56E-08	7,88E-09	5,56E-10	2,25E-09	2,14E-09	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	2,67E-09	4,23E-09	1,91E-09	3,32E-10	-1,43E-08	5,76E-08
HTnCE (CTUh/FU)	1,45E-06	2,37E-07	1,42E-08	5,84E-08	7,54E-08	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	6,55E-08	1,64E-07	4,13E-08	9,36E-09	-2,37E-07	2,17E-06
Land Use Related impacts (dimension less)	4,27E+02	2,14E+02	1,93E+01	6,96E+01	3,20E+01	MND	0,00E+00	MND	0,00E+00	MND	0,00E+00	MND	1,62E+01	1,30E+02	5,77E+01	3,84E+01	-2,34E+02	1,00E+03

HTCE = Human Toxicity – cancer effects; HTnCE = Human Toxicity – non cancer effects; ETF = Ecotoxicity – freshwater; (potential comparative toxic unit)
PM = Particulate Matter (Potential incidence of disease due to PM emissions);
IRHH = Ionizing Radiation – human health effects (Potential Human exposure efficiency relative to U235);

Environmental impact categories explained

	Global Warming Potential	The global warming potential of a gas refers to the total contribution to global warming resulting from the emission of one unit of that gas relative to one unit of the reference gas, carbon dioxide, which is assigned a value of 1. It is split up in 4: - Global Warming Potential total (GWP-total) which is the sum of GWP-fossil, GWP-biogenic and GWP-luluc - Global Warming Potential fossil fuels (GWP-fossil) : The global warming potential related to greenhouse gas (GHG) emissions to any media originating from the oxidation and/or reduction of fossil fuels by means of their transformation or degradation (e.g. combustion, digestion, landfilling, etc). - Global Warming Potential biogenic (GWP-biogenic) : The global warming potential related to carbon emissions to air (CO2, CO and CH4) originating from the oxidation and/or reduction of aboveground biomass by means of its transformation or degradation (e.g. combustion, digestion, composting, landfilling) and CO2 uptake from the atmosphere through photosynthesis during biomass growth – i.e. corresponding to the carbon content of products, biofuels or above ground plant residues such as litter and dead wood.[2] - Global Warming Potential land use and land use change (GWP-luluc): The global warming potential related to carbon uptakes and emissions (CO2, CO and CH4) originating from carbon stock changes caused by land use change and land use. This sub-category includes biogenic carbon exchanges from deforestation, road construction or other soil activities (including soil carbon emissions).
	Ozone Depletion	Destruction of the stratospheric ozone layer which shields the earth from ultraviolet radiation harmful to life. This destruction of ozone is caused by the breakdown of certain chlorine and/or bromine containing compounds (chlorofluorocarbonsor halons), Which break down when they reach the stratosphere and then catalytically destroy ozone molecules.
	Acidification potential	Acid depositions have negative impacts on natural ecosystems and the man-made environment incl. buildings. The main sources for emissions of acidifying substances are agriculture and fossil fuel combustion used for electricity production, heating and transport.
	Eutrophication potential	The potential to cause over-fertilization of water and soil, which can result in increased growth of biomass and following adverse effects. It is split up in 3: - Eutrophication potential – freshwater: The potential to cause over-fertilization of freshwater, which can result in increased growth of biomass and following adverse effects. - Eutrophication potential – marine: The potential to cause over-fertilization of marine water, which can result in increased growth of biomass and following adverse effects. - Eutrophication potential – terrestrial: The potential to cause over-fertilization of soil, which can result in increased growth of biomass and following adverse effects.
	Photochemical ozone creation	Chemical reactions brought about by the light energy of the sun creating photochemical smog. The reaction of nitrogen oxides with hydrocarbons in the presence of sunlight to form ozone is an example of a photochemical reaction.
	Abiotic depletion potential for non-fossil ressources	Consumption of non-renewable resources, thereby lowering their availability for future generations. Expressed in comparison to Antimonium (Sb). The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.
	Abiotic depletion potential for fossil ressources	Measure for the depletion of fossil fuels such as oil, natural gas, and coal. The stock of the fossil fuels is formed by the total amount of fossil fuels, expressed in Megajoules (MJ). The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.
	Ecotoxicity for aquatic fresh water	The impacts of chemical substances on ecosystems (freshwater). The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.
	Human toxicity (carcinogenic effects)	The impacts of chemical substances on human health via three parts of the environment: air, soil and water.

[2] Carbon exchanges from native forests shall be modelled under GWP - luluc (including connected soil emissions, derived products or residues), while their CO2 uptake is excluded.

		The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.
	Human toxicity (non-carcinogenic effects)	The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.
	Particulate matter	Accounts for the adverse health effects on human health caused by emissions of Particulate Matter (PM) and its precursors (NOx, SOx, NH3)
	Resource depletion (water)	Accounts for water use related to local scarcity of water as freshwater is a scarce resource in some regions, while in others it is not. The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.
	Ionizing radiation - human health effects	This impact category deals mainly with the eventual impact on human health of low dose ionizing radiation of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.
	Land use related impacts	*The indicator is the "soil quality index" which is the result of an aggregation of* following four aspects: - Biotic production - Erosion resistance - Mechanical filtration - Groundwater The aggregation is done based on a JRC model. The four aspects are quantified through the LANCA model for land use. The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.

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Details of the underlying scenarios used to calculate the impacts

A1 – Raw material supply

This module takes into account the extraction of all raw materials (sand, gravel, cement, water and admixtures) and energy which occur upstream to the studied manufacturing process.

A2 – Transport to the manufacturer

The raw materials are transported to the manufacturing site.

A3 – Manufacturing

This module takes into account the production process (internal transport, weighing and mixing of all raw materials).

A4 – Transport to the building site

The concrete is transported with truck mixers to the jobsite right before installation.

Fuel type and consumption of vehicle or vehicle type used for transport	Truck 16-32 ton 0,260 l diesel / km (Ecoinvent scenario)
Distance	17 km
Capacity utilisation (including empty returns)	Ecoinvent scenario
Bulk density of transported products	Ecoinvent scenario
Volume capacity utilisation factor	Ecoinvent scenario

A5 – Installation in the building

The concrete is pumped into the formwork and compacted. The formwork itself is not included in this study as it is re-used many times. 4% material losses and leftover have been taken into account, it is assumed that half of this material is lost and treated as waste (2% of the reference flow), and half is leftover concrete that is reused internally by the manufacturer in its concrete production.

Ancillary materials for installation (specified by material);	Not applicable
Water use	Not applicable
Other resource use	Not applicable
Quantitative description of energy type (regional mix) and consumption during the installation process	• 21,6 MJ diesel burned for concrete pump • 0,15 kWh electricity from Belgian grid mix for compaction • 1,39 kg diesel burned by truck (concrete mixer)
Waste materials on the building site before waste processing, generated by the product's installation (specified by type)	47,4 kg ready-mixed concrete (2% material loss)
Output materials (specified by type) as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	Not applicable
Direct emissions to ambient air, soil and water	Not applicable
Distance	Not applicable

B – Use stage (excluding potential savings)

Ready-mixed concrete is commonly used in applications such as beams, columns, walls, foundations, slabs, etc. Ready-mixed concrete doesn't need any specific maintenance or cleaning. Most of the concrete is not visible during its lifetime (e.g. foundations, slabs in office buildings or apartments) and doesn't need any specific care or replacements during its life span of 100 years. Since no maintenance, replacement or operational energy use are necessary during the RSL of the product, no environmental impacts occur during these modules.

B1: Module not declared
B2: Ready mixed concrete doesn't need any specific maintenance or cleaning
B3: Module not declared
B4: No replacement is needed
B5: Module not declared
B6: No operational energy use needed

C – End of life

The default scenario provided by the B-PCR, being 5% to landfill and 95% to recycling, has been used as end-of-life scenario.
The B-PCR also provides default scenarios for transport of waste which are:

- 30 km with a 16-32 ton EURO 5 lorry from demolition site to sorting plant/crusher/collection point;
- 50 km with a 16-32 ton EURO 5 lorry from sorting plant to landfill;
- 100 km with a 16-32 ton EURO 5 lorry from sorting plant to incineration plant/energy recovery.

C1: Demolition of 2300 kg concrete
C2-C4: The default scenario provided by the B-PCR describes for the concrete that 95% is recycled and 5% is landfilled.

The burdens of recycling of the concrete (95% * 2300 kg) are included in the C3 module because the end-of-waste state is reached after breaking and seaving of the concrete (inside the system boundaries).

Module C2 – Transport to waste processing					
Type of vehicle (truck/boat/etc.)	Fuel consumption (litres/km)	Distance (km)	Capacity utilisation (%)	Density of products (kg/m³)	Assumptions
Truck 16-32 ton	0,260 l diesel/km (Ecoinvent scenario)	30	Ecoinvent scenario	Ecoinvent scenario	Ecoinvent scenario
Truck 16-32 ton	0,260 l diesel/km (Ecoinvent scenario)	50	Ecoinvent scenario	Ecoinvent scenario	Ecoinvent scenario
Truck 16-32 ton	0,260 l diesel/km (Ecoinvent scenario)	100	Ecoinvent scenario	Ecoinvent scenario	Ecoinvent scenario

End-of-life modules – C3 and C4		
Parameter	Unit	Value
Wastes collected separately	kg	0
Wastes collected as mixed construction waste	kg	2300
Waste for re-use	kg	0
Waste for recycling	kg	2185
Waste for energy recovery	kg	0
Waste for final disposal	kg	115

D – Benefits and loads beyond the system boundaries

The benefits beyond the system boundaries include the avoided production of virgin material (crushed gravel): 95% recycling during end of life + 95% recycling of losses during A5.

Quantitative description of the loads beyond the system boundaries	0
Quantitative description of the benefits beyond the system boundaries	Avoided production of 2230kg of crushed gravel

Additional information on Release of dangerous substances to indoor air, soil and water during the use stage

Indoor air
No emissions to indoor air are expected.

Soil and water
The horizontal standards on measurement of release of regulated dangerous substances from construction products using harmonized test methods are not yet available, therefore the EPD can lack this information (CEN TC 351).

Demonstration of verification

EN 15804+A2 serves as the core PCR	
Independent verification of the environmental declaration and data according to standard EN ISO 14025:2010	
Internal ☐	External☒
Third party verifier: Evert Vermaut Jan Olieslagerslaan 35 1800 Vilvoorde evermaut@vincotte.be	

Application unit

This paragraph gives information on the applied product and how the reference flow relate to different applications. For ready mixed concrete there are 7 applications, all for a fixed 1 m^3 ready mixed concrete with a ratio to the declared unit of 1 for each application. The 7 different element types for application are:

- Floors
- Foundations
- Floors, galleries, balconies, walkways
- Beams and columns
- Outer walls
- Roofs
- Ground finishing (outside)

Additional information on reversibility

For the application unit a qualitative assessment of the reversibility can be given (based on BAMB – buildings as material banks). This is shown in the table below.

Table 1: Reversibility of the typical Belgian ready-mixed concrete

Reversibility	Simplicity of dissasembly	Speed of dissasembly	Ease of handling (size and weight)	Robustness of material (material resistance to disassembly)
Non-reversible fixing	Simple dissassembly use of dismantling tools required	speedy disassembly	handling requires mechanical devices	n/a: the element is not reversible

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General information

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Based on following PCR documents	EN 15804+A2:2019 NBN/DTD B 08-001 and its complement EN16757:2017
PCR review conducted by	Federal Public Service of Health and Environment & PCR Review committee
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Identification of the project report	Life cycle assessment of typical Belgian ready-mixed concrete (VITO, 2021)
Verification	External independent verification of the declaration and data according to EN ISO 14025 and relevant PCR documents
Name of the third party verifier Date of verification	Evert Vermaut (Vinçotte) 23/03/2021
www.b-epd.be	**www.environmentalproductdeclarations.eu**

Comparing EPDs is not possible unless they are conform to the same PCR and taking into account the building context.
The program operator cannot be held responsible for the information supplied by the owner of the EPD nor LCA practitioner.

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