FINNISH CONCRETE ASSOCIATION

BY LOW CARBON CLASSIFICATION®

PART 1
Background report 2024

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This background report presents the principles of *BY Low carbon Classification®* and input data related to the classification, such as the specific emissions of raw materials, transport, and energy. The specific emissions on which the classification is based may change due to e.g., the evolution of materials. The changes in specific emissions are updated in the BY Low Carbon Calculator immediately after the approval of the Low Carbon Committee, but this background report is updated once a year. Any amendments and changes made after the updating of the background report as well as the updated specific values are posted online at www.vähähiilinenbetoni.fi/ominaisarvot

The guidelines associated with BY Low Carbon Classification® comprise the following parts:
Part 1 *Background report*
Part 2 *Instructions for use for designers and concrete buyer*
Part 3 *Instructions for use for manufacturer of concrete and precast concrete elements*
Part 4 *Instructions for use of BY Low Carbon Calculator.*

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CONTENT

PREFACE

BY Low Carbon Classification® is a voluntary, national classification system for the declaration of the carbon dioxide emissions of concrete. The purpose of the classification system is to facilitate the use of low-carbon concrete, thus reducing the carbon oxide emissions caused by concrete structures.

In BY Low Carbon Classification®, types of concrete are classified into different classes based on their carbon dioxide emissions. The classification system is designed to provide for the industry a consistent method, independent of the concrete manufacturer, to describe different low-carbon types of concrete. Being analogue with concrete strength classes, the classification system facilitates the specification of low-carbon concrete types at the building's design stage. For example, the customer can specify the low-carbon class of concrete for an individual structure or project and then select the concrete supplier in the normal manner.

The BY Low Carbon Class of concrete is determined based on the emission value obtained from the BY-approved calculation program. The Calculator determines the carbon dioxide emissions of a specific concrete mix per one cubic metre [m^3] of concrete.

The classification and the Calculator are only intended for use with ready mix concrete and precast concrete elements manufactured in Finland, as the reference values are based on Finnish raw materials and energy data.

Finnish Concrete Association is in charge of BY Low Carbon Classification®. The classification of ready mix concrete was developed in 2021 and 2022, and the classification of concrete types used in precast concrete elements in 2022 and 2023. The development of the classification has been a collaboration between the Finnish Concrete Association, the Association of Concrete Industry in Finland, and Aalto University. Classification is headed by a steering group consisting of the following members

Jussi Mattila, Association of Concrete Industry in Finland, Chair
Olli-Pekka Aalto, WSP Finland Oy
Tapio Aho, Ramboll Oy
Mika Autio, Rudus Oy
Pekka Haapimaa, Swerock Oy
Markus Haatainen, Lujabetoni Oy
Esa Heikkilä, Finnsementti Oy
Jani Kemppainen, Talonrakennusteollisuus ry (Building Construction)
Janne Kihula, Association of Concrete Industry in Finland/ Precast Element Division
Elli Kinnunen, A-Insinöörit Suunnittelu Oy
Arto Köliö, Renovatek Oy
Mika Lemmetyinen, Finnish Transports Infrastructure Agency
Erkki Luokkanen, Helsinki Building Control Services
Ari Mantila, Association of Concrete Industry in Finland/ ready-mix concrete division
Jouni Punkki, Aalto University

Hannu Rannanjärvi, Consolis Parma Oy
Jani Ruuth, Inspecta Sertifionti Oy
Katriina Tallbacka, Kiwa Inspecta Oy
Lasse Toivanen, City of Helsinki
Mirva Vuori, Finnish Concrete Association, secretary

The specific emissions of raw materials, transports and energy used in the calculations are verified and approved by the *Low Carbon Committee* set up under the Finnish Concrete Association. The Committee also reviews any needs for changes and improvements related to the classification system, the Calculator, and the associated guidelines. The Committee approves the calculation tools used for BY Low Carbon Classification® and acts as a steering group for certification. The following members have been appointed to the Low Carbon Committee:

Jouni Punkki, Aalto University, Chair
Arto Köliö, Renovatek Oy
Katriina Tallbacka, Inspecta Sertifiointi Oy
Ari Mantila, Association of Concrete Industry in Finland
Janne Kihula, Association of Concrete Industry in Finland
Tarja Häkkinen, sberesearch
Mirva Vuori, Finnish Concrete Association, secretary

In order to avoid conflicts of interest, material suppliers or users of the Calculator will not be appointed as members of the Low Carbon Committee.

All material related to the classification system has been collated online at www.vähähiilinenbetoni.fi. The trademarks and logos associated with BY Low Carbon Classification® are owned by the Finnish Concrete Association.

1 PURPOSE AND PRINCIPLES OF BY LOW CARBON CLASSIFICATION®

In BY Low Carbon Classification®, types of concrete are classified according to the amount of their carbon dioxide emissions. The classification is assigned separately for each concrete mix and concrete station. There are five low carbon classes. The classification of ready mix concrete covers a total of 18 types of concrete. The classification of precast concrete elements covers 17 different types of concrete used in precast products. The classification of precast concrete elements only pertains to emissions from concrete materials and energy consumption. BY Low Carbon Classification® is voluntary and can be used at the discretion of the designer, client, or some other party.

Low carbon classes are indicated with the code GWP.NN (GWP = Global Warming Potential). There are five low carbon classes: GWP.REF™, GWP.85™, GWP.70™, GWP.55™, GWP.40™. The GWP.REF™ class is the reference level for each type of concrete, corresponding to the average emission level of Finnish concrete manufacturers at the time the classification is carried out. The emission levels are lower in the low carbon classes than the reference level. Class GWP.85™, for example, indicates that the emissions are at most 85% of the reference level.

Table 1 shows the BY Low Carbon Classes of ready mix concrete types and Table 2 the classes of precast concrete elements. Emissions are expressed in kg CO_2e/m^3. The values are GWP_{total} values as referred to in standard *SFS-EN 15804:2012 + A2:2019* and cover the life cycle modules A1…A3. The reference level also serves as one low-carbon class; the selection of the reference level ensures that the emissions of the concrete used will not exceed the average level of that concrete type.

The principles of Environmental Product Declarations (EPD) are applied to the calculation of emissions, with some exceptions. Contrary to EDPs, only the GWP_{total} emissions are calculated and only EDP modules A1…A3 are included for the classification. Emissions are calculated based on the selected type of concrete mix with waste taken into account as a fixed proportion [%] of the amount of the produced concrete. The calculation covers binders (cement and admixtures), aggregates, additives, and water as raw materials. The emissions caused by the transport of the raw materials as well as the electricity and heating energy consumed in the production of concrete are also included.

The BY Low Carbon Class of the concrete is calculated using the BY Low Carbon Calculator or some other BY-approved calculation program based on the specified emission value. BY Low Carbon Classification® can be used by concrete manufacturers who have obtained the BY Low Carbon Certificate. In other words, an independent third-party controls compliance with the classification guidelines and the validity of the calculations.

It should be noted that the emission values of the classification only refer to the concrete, and not, for example, to reinforcement of concrete structures, transport of concrete or concrete products, or worksite activities. The emission value of the concrete can be

utilised in the emission calculations of buildings, provided it is borne in mind that the emission value only covers the concrete material. Thus, the emission value of concrete is not comparable to the emission values indicated in the EPDs of precast concrete elements, for example, because the latter also include emissions from reinforcement, anchor elements, and any insulation materials.

The low carbon class does not invalidate other requirements that apply to concrete. Strength and durability properties (such as exposure classes), for example, must be fulfilled regardless of the low carbon class.

It should be noted, however, that the selection of a low-carbon concrete also affects the other properties of the concrete, such as strength development.

Table 1. Types of ready mix concrete covered by BY Low Carbon Classification® and limit values of BY Low Carbon Classes. The values are GWP_{total} values and include modules A1…A3. The values are given in kg CO_2e/m^3.

	kg CO_2e/m^3				
TYPE OF CONCRETE	**GWP.REF™**	**GWP.85™**	**GWP.70™**	**GWP.55™**	**GWP.40™**
C20/25 - Non-air-entrained	**210**	**180**	**145**	**115**	**85**
C25/30 - Non-air-entrained	**230**	**195**	**160**	**125**	**90**
C30/37 - Non-air-entrained	**255**	**215**	**180**	**140**	**100**
C35/45 - Non-air-entrained	**285**	**240**	**200**	**155**	**115**
C40/50 - Non-air-entrained	**305**	**260**	**215**	**170**	**120**
C45/55 - Non-air-entrained	**320**	**270**	**225**	**175**	**130**
C50/60 - Non-air-entrained	**340**	**290**	**240**	**185**	**135**
C30/37 - Air-entrained	**290**	**245**	**205**	**160**	**115**
C35/45 - Air-entrained	**330**	**280**	**230**	**180**	**130**
C40/50 - Air-entrained	**355**	**300**	**250**	**195**	**140**
C45/55 - Air-entrained	**375**	**320**	**265**	**205**	**150**
C50/60 - Air-entrained	**395**	**335**	**275**	**215**	**160**
C30/37 P0	**270**	**230**	**190**	**150**	**110**
C30/37 P30	**300**	**255**	**210**	**165**	**120**
C35/45 P0	**300**	**255**	**210**	**165**	**120**
C35/45 P30	**330**	**280**	**230**	**180**	**130**
C35/45 P50	**340**	**290**	**240**	**185**	**135**
C45/55 P50	**375**	**320**	**265**	**205**	**150**

Table 2. Types of concrete used in precast concrete elements covered by BY Low Carbon Classification® and limit values of BY Low Carbon Classes. The values are GWP_{total} values and include modules A1…A3. The values are given in kg CO_2e/m^3.

		kg CO_2e/m^3				
	PRODUCT GROUP	**GWP.REF™**	**GWP.85™**	**GWP.70™**	**GWP.55™**	**GWP.40™**
Hollow-core and floor plates	C40/50	**270**	**230**	**190**	**150**	**110**
	C50/60	**295**	**250**	**205**	**160**	**120**
	C60/75	**340**	**290**	**240**	**185**	**135**
Frame products[1)]	C35/45	**315**	**270**	**220**	**175**	**125**
	C40/50	**335**	**285**	**235**	**185**	**135**
	C45/55	**350**	**300**	**245**	**195**	**140**
	C50/60	**360**	**305**	**250**	**200**	**145**
	C55/67	**375**	**320**	**265**	**205**	**150**
	C60/75	**390**	**330**	**275**	**215**	**155**
Other precast elements[2)]	C30/37	**290**	**245**	**205**	**160**	**115**
	C30/37 air-entrained	**310**	**265**	**215**	**170**	**125**
	C35/45	**320**	**270**	**225**	**175**	**130**
	C35/45 air-entrained	**340**	**290**	**240**	**185**	**135**
	C40/50	**350**	**300**	**245**	**195**	**140**
Walls, white cement	C30/37	**505**	**430**	-	-	-
	C35/45	**525**	**445**	-	-	-
	C40/50	**555**	**470**	-	-	-

[1)] Frame products: precast columns, precast beams, precast TT and HTT slabs.
[2)] Other precast elements: wall panels, solid slabs, technical shafts, foundation elements, and lift shaft elements.

2 CALCULATION OF GWP EMISSIONS

GWP emissions are calculated with the BY Low Carbon Calculator found at www.vähähiilinenbetoni.fi. The emissions can also be calculated using some other calculation tools approved by the Finnish Concrete Association and verified by a third party. Individual calculation results obtained with other calculation tools approved by the Finnish Concrete Association may not differ from the results of the BY Low Carbon Calculator by more than ±5 kg CO_2e/m^3. More information is provided in Section 4 of Part 3.

The calculation is specific to each type of concrete and concrete station. The emissions are calculated individually for each concrete mix based on the target values of the composition of the mix, but taking the safety margin of the emission value, if any, into account. The manufacturer defines the safety margin separately for each concrete mix. The safety margin should be determined taking into account that the true emission value obtained in random tests must not exceed the target emission value by more than 5 kg CO_2e/m^3.

For each raw material, the following shall be included

- production of raw material (= quantity of raw material [kg/m^3] * specific emission [kg CO_2e/kg]) * waste [%]
- transport of raw material to concrete station (= quantity of raw material [kg/m^3] * transport distance [km] * specific emission [$kg/CO_2e/t$ km]) * waste [%].

For the transport of raw materials, the different modes of transport and all stages of transport are taken into consideration; for example, the cement can be transported to the terminal by sea and then further to the concrete station by road. A list of transport distances of raw materials outside Finland can be found in Appendix 1 and at www.vähähiilinenbetoni.fi/ominaisarvot.

The calculations cover energy consumption at the concrete station (electricity and heating energy) using standardised average consumption values, but emission values specific to the energy mode (see Section 2.3).

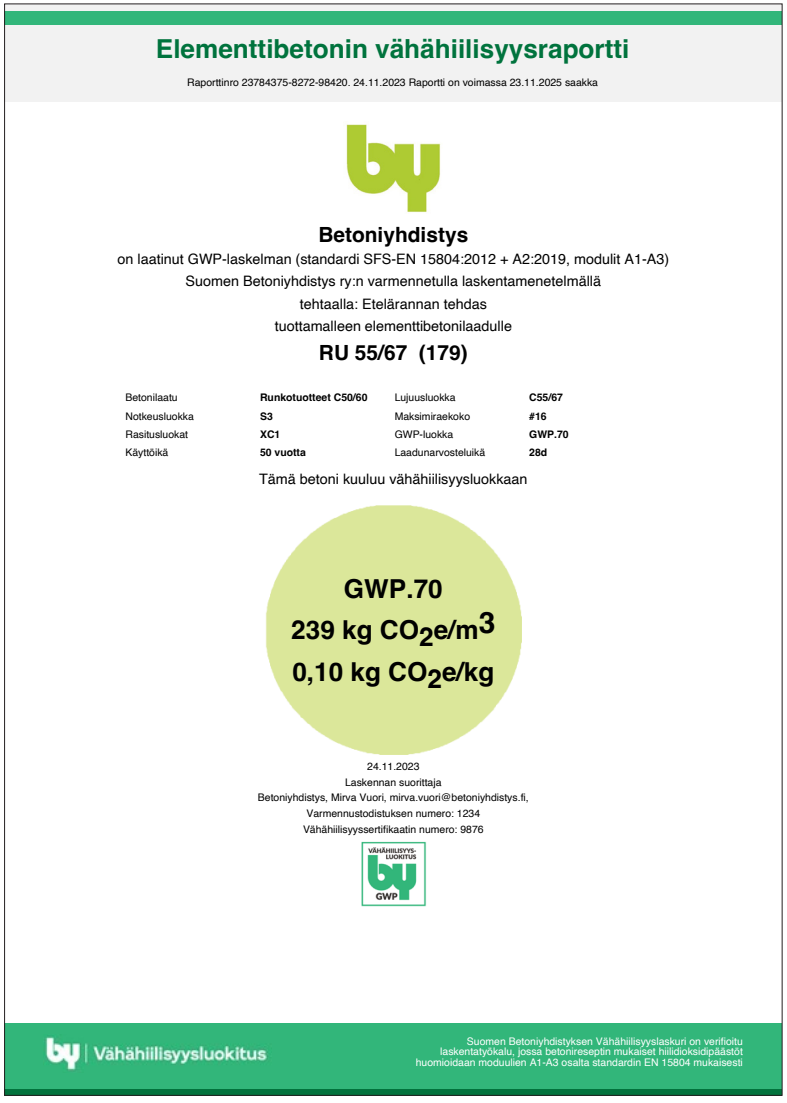
For concrete waste, a fixed value of 2% is used (see also Section 2.4). The volumes of plastic and mixed waste from the production of concrete are so small that they are not included in the calculations. For the concrete used in precast concrete elements, the average waste values of the industry for each specific product group are primarily used. The waste percentage is 10% for hollow-core and thin-shell slabs, and 2% for wall and frame products.

The result of the calculation expresses the total emissions in kg CO_2e/m^3 (GWP_{total}). This value is used in the classification. The result value is also given in kg CO_2e/kg of concrete. The density used is the density indicated for the concrete mix. As emission values indicated in kg are used in some emission data bases, such as the *CO2data.fi* data base, the values are comparable with the data base values.

The emissions for the different modules are also presented in conformity with Environmental Product Declarations – The BY Calculator rounds all A1...A3 sum totals to the nearest whole number:

- A1: Raw material supply
- A2: Raw material transport
- A3: Emissions from manufacturing process.

The emissions resulting from the transport of concrete and precast concrete elements to the worksite (module A4) are not included in the classification of concrete when using BY Low Carbon Classification®. The analysis of limit values does not consider emissions from the pumping of concrete either. However, emissions from worksite transports can be calculated with the BY Low Carbon Calculator. Figures 1 and 2 present reports from the BY Low Carbon Calculator.



Elementtibetonin vähähiilisyysraportti

Raporttinro 23784375-8272-98420. 24.11.2023 Raportti on voimassa 23.11.2025 saakka

Betoniyhdistys

on laatinut GWP-laskelman (standardi SFS-EN 15804:2012 + A2:2019, modulit A1-A3)
Suomen Betoniyhdistys ry:n varmennetulla laskentamenetelmällä
tehtaalla: Etelärannan tehdas
tuottamalleen elementtibetonilaadulle

RU 55/67 (179)

Betonilaatu	**Runkotuotteet C50/60**	Lujuusluokka	**C55/67**
Notkeusluokka	**S3**	Maksimiraekoko	**#16**
Rasitusluokat	**XC1**	GWP-luokka	**GWP.70**
Käyttöikä	**50 vuotta**	Laadunarvosteluikä	**28d**

Tämä betoni kuuluu vähähiilisyysluokkaan

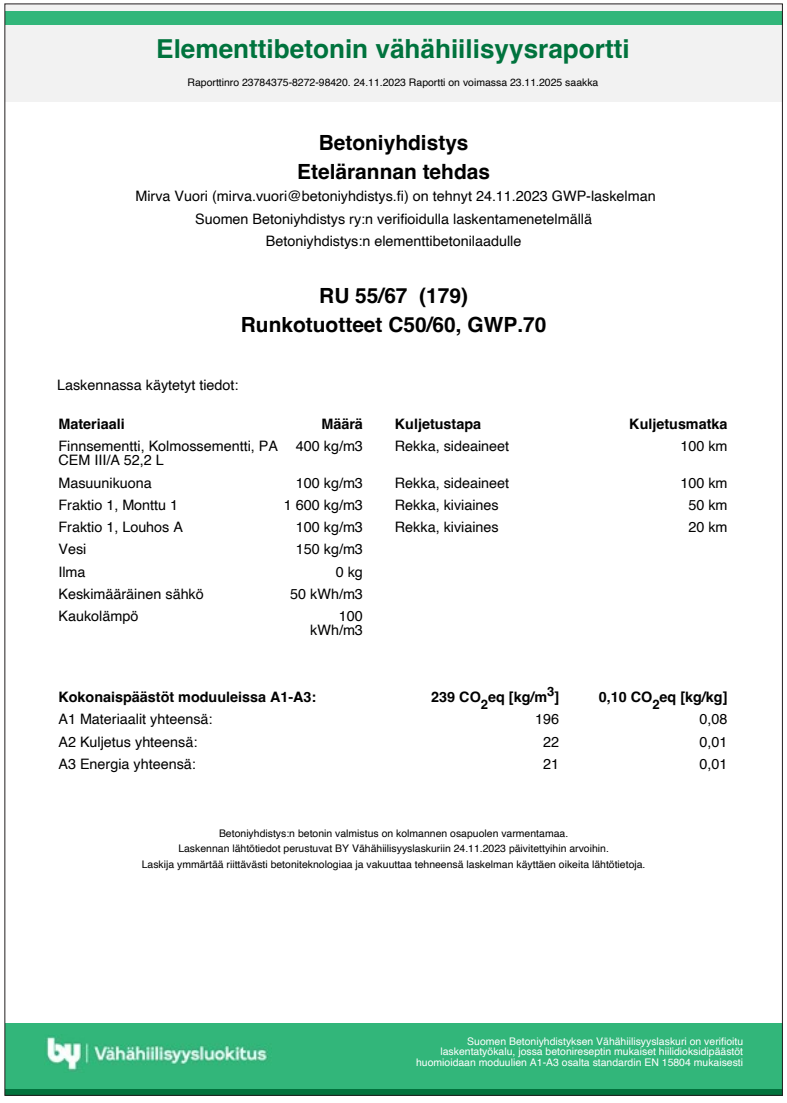
GWP.70
239 kg CO_2e/m^3
0,10 kg CO_2e/kg

24.11.2023
Laskennan suorittaja
Betoniyhdistys, Mirva Vuori, mirva.vuori@betoniyhdistys.fi,
Varmennustodistuksen numero: 1234
Vähähiilisyyssertifikaatin numero: 9876

Vähähiilisyysluokitus

Suomen Betoniyhdistyksen Vähähiilisyyslaskuri on verifioitu laskentatyökalu, jossa betonireseptin mukaiset hiilidioksidipäästöt huomioidaan moduulien A1-A3 osalta standardin EN 15804 mukaisesti

Figure 1. Customer report (certificate) from BY Low Carbon Calculator.



Elementtibetonin vähähiilisyysraportti

Raporttinro 23784375-8272-98420. 24.11.2023 Raportti on voimassa 23.11.2025 saakka

Betoniyhdistys
Etelärannan tehdas

Mirva Vuori (mirva.vuori@betoniyhdistys.fi) on tehnyt 24.11.2023 GWP-laskelman
Suomen Betoniyhdistys ry:n verifioidulla laskentamenetelmällä
Betoniyhdistys:n elementtibetonilaadulle

RU 55/67 (179)
Runkotuotteet C50/60, GWP.70

Laskennassa käytetyt tiedot:

Materiaali	**Määrä**	**Kuljetustapa**	**Kuljetusmatka**
Finnsementti, Kolmossementti, PA CEM III/A 52,2 L	400 kg/m3	Rekka, sideaineet	100 km
Masuunikuona	100 kg/m3	Rekka, sideaineet	100 km
Fraktio 1, Monttu 1	1 600 kg/m3	Rekka, kiviaines	50 km
Fraktio 1, Louhos A	100 kg/m3	Rekka, kiviaines	20 km
Vesi	150 kg/m3		
Ilma	0 kg		
Keskimääräinen sähkö	50 kWh/m3		
Kaukolämpö	100 kWh/m3		

Kokonaispäästöt moduuleissa A1-A3:	**239 CO_2eq [kg/m^3]**	**0,10 CO_2eq [kg/kg]**
A1 Materiaalit yhteensä:	196	0,08
A2 Kuljetus yhteensä:	22	0,01
A3 Energia yhteensä:	21	0,01

Betoniyhdistys:n betonin valmistus on kolmannen osapuolen varmentamaa.
Laskennan lähtötiedot perustuvat BY Vähähiilisyyslaskuriin 24.11.2023 päivitettyihin arvoihin.
Laskija ymmärtää riittävästi betoniteknologiaa ja vakuuttaa tehneensä laskelman käyttäen oikeita lähtötietoja.

Vähähiilisyysluokitus

Suomen Betoniyhdistyksen Vähähiilisyyslaskuri on verifioitu laskentatyökalu, jossa betonireseptin mukaiset hiilidioksidipäästöt huomioidaan moduulien A1-A3 osalta standardin EN 15804 mukaisesti

Figure 2. Concrete plant report from BY Low Carbon Calculator.

2.1 SPECIFIC EMISSIONS OF RAW MATERIALS

The specific emissions of raw materials approved by the Low Carbon Committee are collected in Table 3. Corresponding data on specific emissions that are updated more frequently are provided at www.vähähiilinenbetoni.fi/ominaisarvot.

The emission values of cements contribute significantly to the GWP emissions of concrete and are therefore verified once a year. The specific emissions of other raw materials are also reviewed in this connection, if more current data are available. As a rule, emission data are taken from verified EPDs, if available, of from the *Construction CO2data.fi* data base. For cements, the official verified emission data provided by the cement manufacturer can also be used, as the EPDs are not necessarily updated every year.

BY Low Carbon Classification® is open for all concrete raw materials used in Finland which conform to SFS-EN 206. New cements introduced to the market, for example, are added in the calculation program at the request of the manufacturer, marketer, or user. Reliable emission data, such as a verified EPD, must be available on new materials.

Any changes and amendments in specific emission values are approved by the BY Low Carbon Committee (see Section 6).

The BY Low Carbon Calculator uses pre-defined values for specific emissions. The user cannot modify the specific emission values in the Calculator. This is so as to ensure the maximum reliability and comparability of the calculations.

Table 3. Specific emissions of raw materials. In the Table, LPR = Lappeenranta, PA = Parainen

Raw material group	Raw material	Type of cement	EN15804 type (2012 or 2019)	Specific emission [kg CO_2e/kg]	Source	Quality of data (scale: very bad…good)
Cements	**Finnsementti**					
	Kolmossementti	CEM III/A 52,5 L	+A2:2019	0.446	1)	good
	Ykkössementti	CEM I 42,5 R	+A2:2019	0.768	1)	good
	Finnsementti, Oiva, PA	CEM II/B-M (S-LL) 42,5N	+A2:2019	0.567	2)	good
	Finnsementti, Oiva, LPR	CEM II/B-M (S-LL) 42,5N	+A2:2019	0.526	2)	good
	Finnsementti, Pika, PA	CEM I 52,5 R	+A2:2019	0.776	2)	good
	Finnsementti, Pika, LPR	CEM I 52,5 R	+A2:2019	0.704	2)	good
	Finnsementti, Rapid, PA	CEM II/A-LL 42,5 R	+A2:2019	0.702	2)	good
	Finnsementti, Rapid, LPR	CEM II/A-LL 52,5 N	+A2:2019	0.660	2)	good
	Finnsementti, SR	CEM I 42,5 N – SR3	+A2:2019	0.711	2)	good
	Finnsementti, Valkosementti	CEM I 52,5 R - SR5	+A2:2019	1.04	3)	good
	Schwenk					
	Rapid	CEM I 52,5 N	+A2:2019	0.705	4)	good
	CEM III	CEM III/B 32,5N -LH/SR	+A2:2019	0.235	7)	good
	CEM II	CEM II/A-M (S-LL) 52,5N	+A2:2019	0.619	8)	good
	Viridiscement	CEM II/ B-M (S-LL) 52,5 N	+A2:2019	0,524	23)	
	Scandinavian Cement					
	CEM I 42,5 R	CEM I 42,5 R	+A1:2012	0.899	5)	fair
	CEM I 52,5 SR	CEM I 52,5 SR	+A1:2012	0.892	6)	fair
	Cimsa					
	Super White	CEM I 52,5 R	+A2:2019	1.172	21)	good

Raw material group	Raw material	Type of cement	EN15804 type (2012 or 2019)	Specific emission [kg CO_2e/kg]	Source	Quality of data (scale: very bad…good)
Admixtures	Blast furnace slag		+A2:2019	0.069	1)	good
	Fly ash		-	0.0053	9)	very bad
	Silica		-	0.0053	10)	very bad
	Calcium carbonate filler		-	0.011	11)	fair
Aggregates	Sand		-	0.004	12)	good
	Natural aggregates and crushed gravel		-	0.004	12)	good
	Bedrock aggregates (macadam and crushed stone)		-	0.006	13)	good
	Crushed concrete		+A2:2019	0.005	13a)	good
Water	Water production		-	0.009	22)	good
Additives, generic values	Superplasticiser		+A2:2019	1.530	14)	good
	Air-entraining agent		+A2:2019	0.439	15)	good
	Set retarder		+A2:2019	1.230	16)	good
	Set accelerator		+A2:2019	1.340	17)	good
	Hardening accelerator		+A2:2019	1.790	18)	good
	Water resisting admixture		+A2:2019	2.670	19)	good
Additives, product-specific values	Master X-Seed 100	Hardening accelerator	+A2:2019	0.726	20)	good

1) Finnsementti Oy. https://finnsementti.fi/palvelut/ymparisto/sementtien-ymparistoselosteet/. Publication date 28.10.2022. In accordance with ISO 14025 and EN 15804:2012+A2:2019
2) Finnsementti Oy. https://finnsementti.fi/palvelut/ymparisto/sementtien-ymparistoselosteet/. Publication date 1.9.2021. In accordance with ISO 14025 and EN 15804:2012+A2:2019
3) Environmental Product Declaration. Aalborg White cement CEM I 52.5 R – SR5 (EA), Aalborg Portland A/S. Publishing date: 25.3.2021. Valid until: 12.3.2026
4) Environmental Product Declaration. CEM I 52.5 N Schwenk Latvija SIA. Publication date: 2023-9-11, Valid until: 2027-10-11 EN 15804:2012 + A2:2019. Contrary to what is declared in the EDP, the same specific emissions presented in the CO2data.fi data base are applied to transports as with other cements.
5) Environmental Product Declaration. Portland cement CEM I 42.5R. AB Akmenes Cementas. Publication: October 2020. Validity October 2025.
6) Environmental Product Declaration. Holcim Sulfo 5 R Lägerdorf. Holcim Deutchland GmbH. Date of issue: 2020-07-07.
7) Environmental Product Declaration. Low heat of hydration and sulfate resisting blast furnace cement CEM III/B 32,5N – LH/SR. AB Akmenes Cementas. Publication date: 2021-04-26. Valid until: 2026-04-26. Contrary to what is declared in the EDP, the same specific emissions presented in the CO2data.fi data base are applied to transports as with other cements.
8) Environmental Product Declaration. CEM II/A-M(S-LL) 52.5 N Schwenk Latvija SIA. Publication date: 2023-9-11, Valid until: 2028-9-11 EN 15804:2012+A2:2019. Contrary to what is declared in the EDP, the same specific emissions presented in the CO2data.fi data base are applied to transports as with other cements.
9) Environmental impact of concrete structures. 1998. Finnish Association of Construction Product Industries RTT. (Fly ash from coal-fired power plants) Low Carbon Committee 29.4.2022.
10) Silica produces no emissions and has no emission value. The value used is that of fly ash which is a comparable product in terms of the production process. Low Carbon Committee 29.4.2022.
11) GCCA's EPD-tool, declared by Ulla Leveelahti, Finnsementti Oy, 18.3.2022. Low Carbon Committee 29.4.2022
12) CO2data.fi; Products for groundworks and landscape construction, Gravel and sand 12.5.2022
13) CO2data.fi; Mineral and glass products, Crushed products, 12.5.2022
13a) Environmental Product Declaration Demorock, Purkupiha Oy, Publication date: 2022-5-24, Valid until: 2027-5-24 EN 15804:2012
14) Environmental Product Declaration. Concrete admixtures – Plasticizer and Superplasticizers. European Federation of Concrete Admixtures Associations Ltd. (EFCA). Declaration number: EPD-EFC-20210198-IBG1-EN Issue date: 16.12.2021. Valid to: 15.12.2026. In accordance with ISO 14025 and EN 15804:2012+A2:2019
15) Environmental Product Declaration. Concrete admixtures – Air entrainers. European Federation of Concrete Admixtures Associations Ltd. (EFCA). EPD-EFC-20210193-IBG1-EN. Issue date: 16.12.2021. Valid to: 15.12.2026. In accordance with ISO 14025 and EN 15804:2012+A2:2019
16) Environmental Product Declaration. Concrete admixtures – Retarders. European Federation of Concrete Admixtures Associations Ltd. (EFCA). EFC-20210195-IBG1-EN Issue date: 16.12.2021. Valid to: 15.12.2026. In accordance with ISO 14025 and EN 15804:2012+A2:2019
17) Environmental Product Declaration. Concrete admixtures – Set Accelerators. European Federation of Concrete Admixtures Associations Ltd. (EFCA). EPD-EFC-20210194-IBG1-EN Issue date: 16.12.2021. Valid to: 15.12.2026. In accordance with ISO 14025 and EN 15804:2012+A2:2019
18) Environmental Product Declaration. Concrete admixtures – Hardening Accelerators. European Federation of Concrete Admixtures Associations Ltd. (EFCA). EPD-EFC-20210196-IBG1-EN Issue date: 16.12.2021. Valid to: 15.12.2026 In accordance with ISO 14025 and EN 15804:2012+A2:2019
19) Environmental Product Declaration. Concrete admixtures – Water Resisting Admixtures. European Federation of Concrete Admixtures Associations Ltd. (EFCA). Issue date: 16.12.2021. Valid to: 15.12.2026 In accordance with ISO 14025 and EN 15804:2012+A2:2019
20) Environmental Product Declaration. Master X-Seed 100, Master Builders Solutions Deutschland GmbH, Issue date: 17.5.2022. Valid to: 17.5.2027 In accordance with EN 15804+A2 & ISO 14025 / ISO 21930
21) Environmental Product Declaration. Cimsa Super White CEM I 52,5 R, White Portland Cement, Issue date: 25.10.2021. Valid to: 24.10.2026 In accordance with ISO 14025 and EN 15804:2012 +A2:2019
22) openco2.net / HSY, Water production, 14.8.2023
23) Environmental Product Declaration. CEM II/B-M (S-LL) 52.5 N Schwenk Sverige AB. Publication date: 2024-1-8, Valid until: 2029-1-8 EN 15804:2012 + A2:2019. Contrary to what is declared in the EDP, the same specific emissions presented in the CO2data.fi data base are applied to transports as with other cements.

2.2 RAW MATERIAL TRANSPORT

For raw material transports, the specific emissions presented in the *Construction CO2data.fi* data base are used. The Low Carbon Committee may, at their discretion, accept also other sources for the specific emissions of transport. The transport distance as well as the mode of transport are selected on a case-by-case basis. The specific emissions used are shown in Table 4.

For road transports of aggregates, cements, and admixtures, a 50% load is used on a round trip. A 100% load (full load) is assumed in one direction and a 0% load (no load) in the other direction. However, only the outbound distance is entered in the calculation program and the program automatically includes the total emissions from transport.

For transports by sea and rail, a full load is only calculated in one direction. Thus, only the outbound distance is entered in the calculation program also for these modes, and the program automatically includes the emissions.

Table 4. Specific emissions from raw material transports.

Mode of transport	Specific emission [kg CO_2e/tn km]	Source/Remark	Date of source
Lorry; cement and admixtures	0.079	Co2data.fi: transport, semitrailer, load 50%, road operation. Round trip included.	30.3.2022
Lorry; aggregates	0.085	Co2data.fi: transport, dump truck, load 50%, road operation. Round trip included.	30.3.2022
Ship; cement	0.014	Co2data.fi: transport, bulk carrier, medium-sized	30.3.2022
Ship; container ship	0.045	Co2data.fi: transport, container ship, 1 000 TEU	30.3.2022
Train; cement and aggregates	0.022	Co2data.fi: transport, container train, diesel	30.3.2022
Delivery truck	0.160	Co2data.fi: transport, large delivery truck, load 50%, street operation. Round trip included.	30.3.2022
Mixer truck, street operation	0.336 [kg CO_2e/m^3 km]	CO2data.fi: transport, rear dump truck, load 50%, street operation. Return trip and concrete density 2.4 t/m^3 included.	25.10.2023
Mixer truck, road operation (over 10 km distances)	0.204 [kg CO_2e/m^3 km]	CO2data.fi: transport, rear dump truck, load 50%, road operation. Return trip and concrete density 2.4 t/m^3 included.	25.10.2023
As additional information, not included in calculator			
Mixer truck, indicative emission value	57.9 [kg CO_2e/h] or 1.93 [kg CO_2e/m^3]*	CO2data.fi/infra *default pumping rate ca. 30 m^3/h.	25.10.2023

2.3 ENERGY CONSUMPTION AND SPECIFIC EMISSIONS

For the consumption of electricity and heating energy, the following average industry values are used for ready mix concrete:

- electricity: 7 kWh/m³
- heating energy: 11 kWh/m³.

For precast concrete elements, the corresponding average industry values are

- electricity: 50 kWh/m³
- heating energy: 100 kWh/m³

The values are based on analyses of the energy consumption of manufacturers of concrete and precast concrete elements. They are average vales on an annual level; in the winter, the consumption of heating energy, in particular, is higher than during the summer season. The values represent the average industry levels on an annual basis, since it is not usually possible to forecast the precise time of production of concrete. It is difficult to use exact, plant-specific energy consumption data, as energy consumption at the concrete station is not necessarily differentiated from consumption in the office, for example. Also, variation in energy consumption is high between the seasons, because the aggregates require heating during cold periods. Overall, energy consumption is low in the production of concrete and thus, the use of average values is not a significant source of error in the emission values.

The manufacturer can opt to use actual energy consumption data. In this case, the data must be verified by an external expert. The analysis period must be one year. For the verification of the data, documentation is required indicating the consumption of electricity and/or heating energy in kWh/m^3. A defined consumption value can be used for electricity or for heating energy or for both.

The concrete manufacturer selects the source of energy to be used. For electricity, it is possible to use the specific emissions of average electricity which changes annually and can be found in the *CO2data.fi* data base. The value covers also green electricity. The specific emissions used for electricity and heating energy are presented in Table 5. The specific emissions used for the transport of energy are presented in Table 6. The average energy consumption is in the BY Low Carbon Calculator given in kWh/m^3.

The specific emissions from the transport of light fuel oil and bioenergy (i.e., wood chips) according to CO2data.fi [kg CO_2e/t km] are in the BY Calculator given as modified values and have been converted into the unit [kg CO_2e/kWh km] by including the calorific values [kWh/t] of the fuels. Calculation formula:

Modified value [kg CO_2e/kWh km] = Specific emissions from transport [kg CO_2e/t km] / calorific value of fuel [t/kWh]

where emissions from transport (CO2data.fi) = 0.079 [kg CO_2e/t km]
And the calorific value of fuel for wood chips:

8.5 [MJ/kg] * 0.27778 [kWh] * 1000 [kg/t],
where 0.27778 kWh equals 1 MJ

and similarly, the calorific value of fuel for light fuel oil:

42.65 MJ/kg * 0.27778 kWh *1000 kg/t,
where 0.27778 kWh equals 1 MJ

The calorific values of the fuels are based on the net calorific values of fuels indicated by Motiva (net calorific value for total tree chips in delivered state 8.5 MJ/kg and for light fuel oil in delivered state 42.65 MJ/kg) and on a conversion coefficient of 3.6MJ = 1 kWh.

In the BY Low Carbon Calculator, the emission values used and shown for energy transports (bioenergy and light fuel oil) are modified values based on the specific values according to CO2data.fi and the calorific values of fuels according to Motiva. The need for this is due to the current calculation method used by the Calculator. For other materials used in the mix, the mass of the raw material being transported is obtained from the mix data, but as regards the energy values referred to above, the equivalent value is in kWh. Because of this, the conversion of the specific value of transport has been necessary for the BY Calculator to enable it to calculate the emission value of the transport from the indicated kWh.

At least for the time being, the Calculator uses as energy consumption values the average values of the industry which may show greater variation than the full proportion of the transport of the energy. Going forward, it will become possible to also use confirmed consumption values specific to each manufacturer.

The modified specific values are presented in Table 6 of the Background Report. Table 6 also presents the unconverted specific value equivalent to the modified values of energy transports; this value can be used in the concrete manufacturer's own calculator.

Table 5. Specific emissions of electricity and heating energy.

Energy	Specific emission [kg CO_2e/kWh]	Source/Remarks	Date of source
Average electricity	0.127	CO2data.fi: electricity, value 2024	8.1.2024
Light fuel oil	0.306	CO2data.fi: energy, fossil fuels, individual heating systems	5.5.2022
Natural gas	0.199	WWF Climate Calculator factors – Finland 2018	31.1.2022
District heating	0.134	CO2data.fi: energy, district heating, value 2024	8.1.2024
Bioenergy	0.027	CO2data.fi: energy, biofuels, individual heating systems	5.5.2022

Table 6. Specific emissions of energy transports.

Mode of transport	Specific emission [kg CO_2e/kWh km]	Source/Remarks	Date of source
By road, wood chips*	3,346E-05	Modified Co2data.fi: transport, semitrailer, load 50%, road operation. Round trip and calorific value per mass included.	25.10.2023
By road, light fuel oil*	6,691E-06	Modified Co2data.fi: transport, semitrailer, load 50%, road operation. Round trip and calorific value per mass included.	25.10.2023
By road, wood chips and light fuel oil	0.079 [kg CO_2e/t km]	CO2data.fi: transport, semitrailer, load 50%, road operation. Round trip included.	8.1.2024

*The modified values are used in the BY Low Carbon Calculator.

2.4 OTHER CALCULATION VALUES

Based on analyses, the amount of concrete waste is estimated to be 2% during modules A1…A3, and thus, waste is included in the emission calculations using a factor of 1.02. The waste is thought to comprise waste from the washing of mixers and trucks, as well as rejected batches of concrete. The same value is used for all manufacturers and it is based on the input data for the verified LCA calculations conducted for the Finnish Concrete Association in 2020.

For the concrete used in precast concrete elements, the average waste values of the industry for each specific product group are used. The waste percentage is 10% for hollow-core and thin-shell slabs, and 2% for wall and frame products. The waste factor is used to multiply all raw material consumption and transport values. The volumes of plastic and mixed waste from the production of concrete are so small that they are not included in the calculations.

The BY Low Carbon Calculator can also be used to calculate the emissions resulting from the transport of concrete (and later precast concrete elements) to the worksite, but their share is not taken into account when comparing the total emissions with the classification limit values. No waste is added to the emission value of worksite transport, as the transport itself causes no waste. For emissions from the pumping of concrete, a fixed value of 1.93 [kg CO_2e/m^3] is used for now as an indicative value. The emissions from pumping cannot be calculated with the calculator. The specific emissions from the transport of concrete to the worksite and from the pumping are shown in Table 4.

3 IMPACT OF CONCRETE PROPERTIES ON EMISSION VALUES

The reference level emissions have been calculated using the average concrete composition of each type of concrete. The calculations of reference levels use a maximum grain size of 16 mm and consistency class S3 for the concrete. For non-air-entrained and air-entrained types of concrete, exposure class XF1 is used, as well as a design life of 50 years, or 100 years for P-rate concrete.

However, the reference values are valid also for other compositions of the type of concrete. In practice, it is possible that different mixes have different classification values, even if the type of concrete is the same in terms of the strength class and air entrainment. For example, the low carbon class of self-compacting C35/45 concrete may differ from that of consistency class S3 concrete of the same type. The low carbon class is specific for each concrete mix and concrete station.

Table 7 assesses the impact of the properties of concrete on emission values. The data are indicative and not used to adjust emission values. However, the data provided can be utilised when looking for a type of concrete with as low emissions as possible. For example, if a maximum aggregate grain size of 32 mm can be used in the structure, the Table helps in assessing how the selection affects the emission value and the possibility of achieving a certain low-emission class.

Table 7. Estimated impact of changes in concrete properties on emissions of concrete. The values are indicative. The impact has been estimated for GWP.REF™ or GWP.85™ emission classes. The difference will be smaller in lower emission classes.

Change	Specified change	Estimated impact on emission value (kg CO_2e/m^3)	Remarks.
Consistency	Change in consistency class: S3 → S4	+5…+15	
	Change in consistency class: S3 → S2	-15…-5	
	Change in consistency class: S3 → self-compacting concrete	+15…+25	
Aggregates	Change in maximum grain size: 16 mm → 8 mm	+15…+25	
	Change in maximum grain size: 16 mm → 32 mm	-10…-5	
Durability	Change in service life: 50 a → 100 a	+5…+15	Longer service life reduces life cycle emissions.
	Change in exposure class: XF1 → XF3	+10…+20	
	Sulphate exposure: XA2 exposure class (SR cement)	+10…+40	Depending on compared type of cement.
	Chloride exposure: XD2 or XS2 exposure class	+10…+30	
Strength development	Specification age: 28 days → 91 days	-50…-20	Use of 91 days makes it possible to increase the proportion of admixtures, which can result in even greater reduction in emissions.
	Specification age: 28 days → 7 days	+20…+40	Use of 7 days restricts the types of cement that can be used.

4 CERTIFICATION OF LOW-CARBON CONCRETE

The compliance of the manufacturing process and the calculation of emissions with the BY Low Carbon Class specification can be verified through certification. The certification of low-carbon concrete can be applied for from a certification body approved by the Finnish Concrete Association. This must be a notified body or a body approved for certification of ready-mix concrete or precast concrete elements. Certification can only be granted for a concrete manufacturing process with a valid certificate related to product approval, such as a verification certificate (for ready-mix concrete) of CE mark (for precast concrete elements). The general certification guidelines and requirements of the certification body apply.

In the initial inspection, the certification body verifies the resources and capabilities of the manufacturer to supply low-carbon concrete, the calculation of at least one low-carbon concrete mix, and the knowledge of the concrete manufacturer on the use of BY Low Carbon Classification®. The BY Low-Carbon Certificate can be granted upon approval of the initial inspection. The certification body carries out inspection visits to verify a representative number of low-carbon calculations and certificates on new types of concrete comparing them with batch reports, and to verify, based on sampling, the compliance of previous low-carbon calculations with the actual batch reports. The certification body carries out a random test on at least one new concrete mix classified since the previous inspection visit as well as on at least one older type of concrete, if there are any. The inspection must cover at least two types of concrete. If there are more than 10 concrete mixes with low-carbon classification, at least 4 concrete mixes must be verified. The verification is implemented by inspecting 5 batch reports for each type of concrete from different days of manufacture. The inspections also include the verification of the accuracy of the input data as well as the accuracy and validity of any input data determined by the manufacturer, such as the transport distance for raw materials or energy consumption data for the plant. Requirements and instructions related to certification are presented in more detail in Part 3, *Instructions to concrete manufacturer*, of the guidelines connected with BY Low Carbon Classification®.

5 AVAILABILITY OF CLASSIFIED TYPES OF CONCRETE

The ability of the concrete industry to achieve the lower low-carbon classes varies between types of concrete. With P-rate concrete types, for example, it is at present impossible, in practice, to achieve the lower classes due to the regulations of the Finnish Transport Infrastructure Agency regarding concrete used in infrastructure.

The availability of classified low-carbon types of concrete is assessed in Figure 3. It provides an indicative estimate of the situation. The estimate will be updated once a year. It can be assumed that the green area will gradually expand to the right and down. There may also be variations in availability between concrete stations and regionally. It is therefore important to emphasise that Figure 3 only provides an estimate of the availability of different types of concrete and concrete manufacturers should be contacted about true availability.

CONCRETE	Specification age	Reference level GWP.REF™	GWP.85™	GWP.70™	GWP.55™	GWP.40™
C20/25 - Non-air-entrained	28 days					
	91 days					
C25/30 - Non-air-entrained	28 days					
	91 days					
C30/37 - Non-air-entrained	28 days					
	91 days					
C35/45 - Non-air-entrained	28 days					
	91 days					
C40/50 - Non-air-entrained	28 days					
	91 days					
C45/55 - Non-air-entrained	28 days					
	91 days					
C50/60 - Non-air-entrained	28 days					
	91 days					
C30/37 - Air-entrained	28 days					
	91 days					
C35/45 - Air-entrained	28 days					
	91 days					
C40/50 - Air-entrained	28 days					
	91 days					
C45/55 - Air-entrained	28 days					
	91 days					
C50/60 - Air-entrained	28 days					
	91 days					
C30/37 P0	28 days					
	91 days					
C30/37 P30	28 days					
	91 days					
C35/45 P0	28 days					
	91 days					
C35/45 P30	28 days					
	91 days					
C35/45 P50	28 days					
	91 days					
C45/55 P50	28 days					
	91 days					

Figure 3. Availability of low-emission types of concrete of different low-emission classes in 2023.

- Probably commonly available
- Probably available from several manufacturers[1]
- Probably available from some manufacturers[1]
- Probably only available as a special project for a specific project[1]

[1] Verify availability in advance.

6 LOW CARBON COMMITTEE

The Board of the Finnish Concrete Association has appointed the *Low Carbon Committee* which is tasked with, for example

- approving the specific emission values used in the calculations
- deciding on any corrective actions on and further development of classification
- deciding on any changes to be made in the BY Low Carbon Calculator and approving other calculation tools used for BY Low Carbon Classification®
- approving the background report, instructions for use, and updates made in them
- acting as the steering group for certification.

The Low Carbon Committee of the Finnish Concrete Association approves any changes and amendments made in specific emission values. The Committee particularly considers the reliability of specific emissions. The Committee may, at its discretion, also approve emission values even if no Environmental Product Declaration is available.

The reports associated with BY Low Carbon Classification® (*Background report, Instructions for concrete buyer, and Instructions for use for concrete manufacturer*) are updated as necessary. The documents and updates made in them are approved by the Low Carbon Committee which also approves the verification bodies of other calculation tools and is in charge of the maintenance of the BY Low Carbon Calculator. A verification is carried out whenever substantial changes are made in the functionalities of the Calculator, or at least every three years. At present, the only approved verification body of calculation tools is AFRY Oy.

The Low Carbon Committee convenes as necessary, and at least once a year.

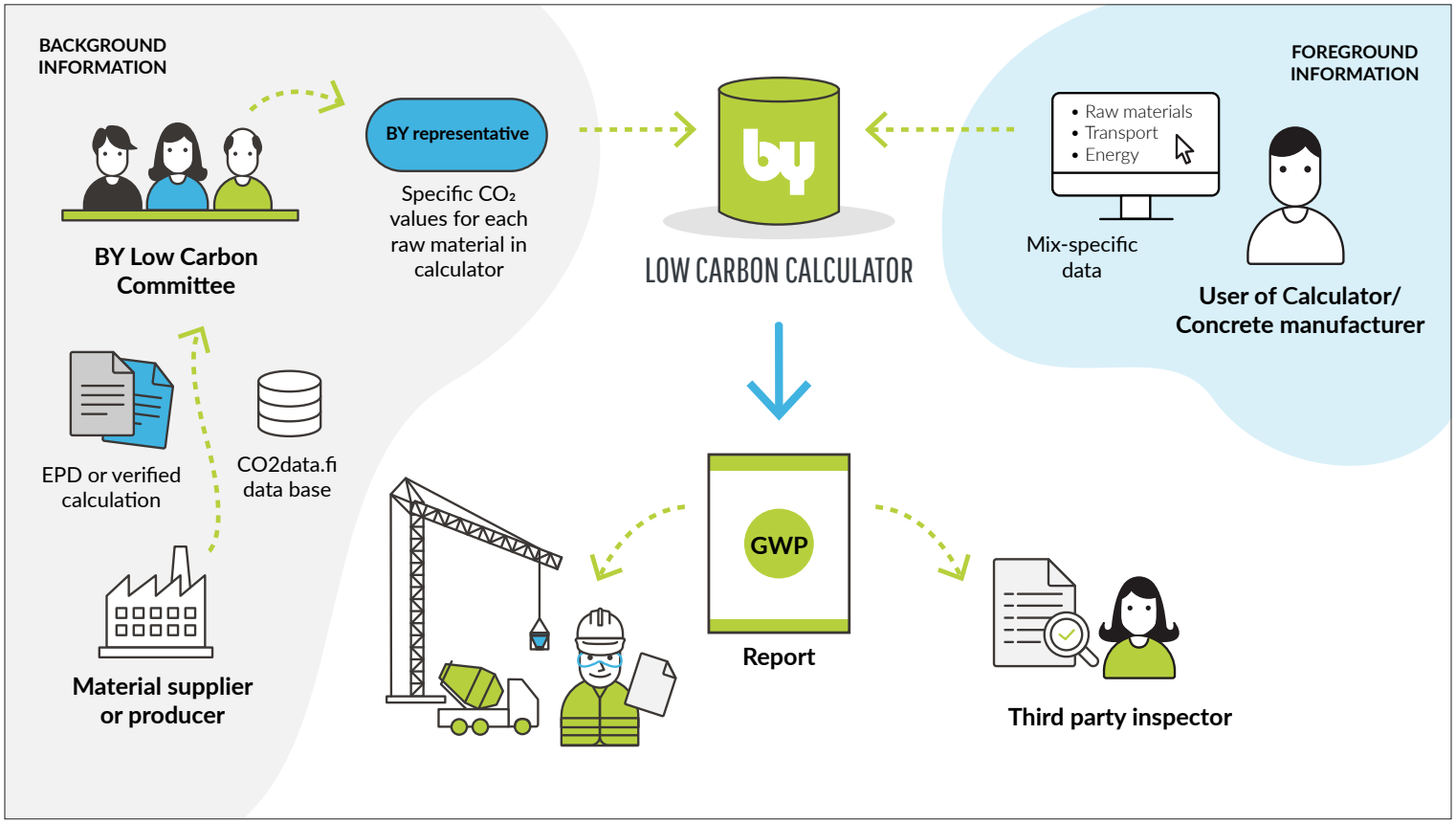


Figure 4. Tasks of various operators in the use of BY Low Carbon Classification®.

APPENDIX 1. TRANSPORT DISTANCES OF RAW MATERIALS IN BY LOW CARBON CALCULATOR

CEMENT

Finnsementti Oy

By sea: Parainen–Oulu:	755 km
By sea: Parainen–Pietarsaari:	550 km
By sea: Parainen–Vaasa:	465 km
By sea: Parainen–Maarianhamina:	175 km
By road: Lappeenranta–Kantvik:	280 km

Finnsementti Oy, Valkosementti

By sea: Aalborg–Hanko, Koverhar	1,200 km

Schwenk

By road: Broceni (Latvia) – Liepaja (Latvia):	104 km
+ by sea: Liepaja (Latvia) – Naantali:	456 km
By road: Broceni (Latvia) – Liepaja (Latvia):	104 km
+ by sea: Liepaja (Latvia) – Loviisa:	625 km

Scandinavian cement

By rail: Akmené (Lithuania) – Klaipeda (Lithuania):	160 km
+ by sea: Klaipeda (Lithuania) – Hamina:	795 km

Cimsa

By sea: Mersin (Turkey) – Rauma	8,200 km

ADMIXTURES

Blast furnace slag

By sea: Raahe–Pori	480 km
By sea: Raahe–Kirkkonummi, Kantvik	840 km

Silica, Finnsementti Oy

By road: Norway–Parainen	1,430 km

Silica, Oy Korate Ab/Elkem Silicon Materials

By road: Norway–Tornio	614 km
By road: Norway–Turku	1,149 km

CRUSHED ROCK

Finnsementti

33R	By road: Kalanti–Parainen	96 km
34R	By road: Taivassalo–Parainen	79 km
35R	By road: Riihimäki–Parainen	188 km
36R	By road: Tervola–Parainen	790 km
42R	By sea: Ballangen (Norway) – Parainen	2,863 km
LK300	By sea: Signhofen (Germany) – Parainen	2,098 km

Transport from the Finnish terminal to the concrete station also to be always included. Distances by sea are indicated as declared by the supplier or on website sea-distances.org.

APPENDIX 2. DENSITIES OF RAW MATERIALS USED IN THE CALCULATOR

Default densities of raw materials in the calculator.

Cements	3,100 kg/m^3
Fly ash	2,300 kg/m^3
Blast furnace slag	2,900 kg/m^3
Silica	2,300 kg/m^3
Aggregates (all fractions)	2,670 kg/m^3
Plasticiser	1,000 kg/m^3
Air-entraining agent	1,000 kg/m^3
Retarder	1,000 kg/m^3
Accelerator	1,000 kg/m^3
Water	1,000 kg/m^3

FINNISH CONCRETE ASSOCIATION