# Statement of Verification

BREG EN EPD No.: 000578 Issue 01

This is to verify that the

**Environmental Product Declaration**

provided by:

C-Probe Systems Limited

is in accordance with the requirements of:

EN 15804:2012+A2:2019

and

BRE Global Scheme Document SD207

This declaration is for:

1kg of LoCem® anode binder

BRE Global Verified EPD

## Company Address


C-Probe Systems Limited,
Unit 2 Wharton Street,
Sherdley Road Industrial Estate,
St Helens,
WA9 5AA


C-PROBE

| | | |
|---|---|---|
| | Emma Baker | 27 June 2024 |
| Signed for BRE Global Ltd | Operator | Date of this Issue |
| 27 June 2024 | | 26 June 2029 |
| Date of First Issue | | Expiry Date |

BRE Global Verified EPD




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ECO PLATFORM EPD VERIFIED

# Environmental Product Declaration

## EPD Number: 000578

## General Information

| EPD Programme Operator | Applicable Product Category Rules |
|---|---|
| BRE Global<br>Watford, Herts<br>WD25 9XX<br>United Kingdom | BRE 2023 Product Category Rules (PN 514 Rev 3.1) for Type III environmental product declaration of construction products to EN 15804:2012+A2:2019. |
| **Commissioner of LCA study** | **LCA consultant/Tool** |
| C-Probe Systems Limited,<br>Unit 2 Wharton Street,<br>Sherdley Road Industrial Estate,<br>St Helens,<br>WA9 5AA | LCA Consultant: Bala Subramanian<br>Tool: BRE LINA A2 |
| **Declared/Functional Unit** | **Applicability/Coverage** |
| 1kg of LoCem® anode binder | Other (please specify). Product specific |
| **EPD Type** | **Background database** |
| Cradle to Gate with options | Ecoinvent 3.8 |

| Demonstration of Verification |
|---|
| CEN standard EN 15804 serves as the core PCR [a] |
| Independent verification of the declaration and data according to EN ISO 14025:2010<br>☐Internal ☒ External |
| (Where appropriate [b])Third party verifier:<br>Roger Connick |
| a: Product category rules<br>b: Optional for business-to-business communication; mandatory for business-to-consumer communication (see EN ISO 14025:2010, 9.4) |

| Comparability |
|---|
| Environmental product declarations from different programmes may not be comparable if not compliant with EN 15804:2012+A2:2019. Comparability is further dependent on the specific product category rules, system boundaries and allocations, and background data sources. See Clause 5.3 of EN 15804:2012+A2:2019 for further guidance |

## Information modules covered.

| Product | | | Construction | | Use stage | | | | | | | End-of-life | | | | | Benefits and loads beyond the system boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Related to the building fabric | | | | | Related to the building | | | | | | | |
| A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | | D |
| Raw materials supply | Transport | Manufacturing | Transport to site | Construction – Installation | Use | Maintenance | Repair | Replacement | Refurbishment | Operational energy use | Operational water use | Deconstruction demolition | Transport | Waste processing | Disposal | | Reuse, Recovery and/or Recycling potential |
| ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☐ | ☐ | ☑ | ☑ | ☑ | ☑ | | ☑ |

Note: Ticks indicate the Information Modules declared.

## Manufacturing site(s)

C-Probe Systems Limited,
Unit 2 Wharton Street,
Sherdley Road Industrial Estate,
St Helens
WA9 5AA

# Construction Product:

## Product Description

AACM binder is the product of alkali-activated cementitious material formulation that is the basis for a range of restoration, build and corrosion protection products.

The formulation has two basic forms:
1. Non-conductive for use as a concrete repair mortar or as a build concrete.
2. Conductive form for use as an anode mortar for use in the restoration or within the build design installed during construction to protect structures from corrosion using galvanic and impressed current cathodic protection.

The formulation uses a variety of feedstocks derived from repurposing wastes from steel (GGBS) as the main constituent and various secondary constituents, including fossil fuels (fly ash), pozzolans (metakaolin, densified microsilica), gypsum, alkalis, and small amounts of cements such as CSA and Portland. The purpose of all these ingredients is to provide sources of silicon, aluminium, calcium, sodium that when activated using a sodium silicate (alkaline) solution harden to form a cross-linked geopolymeric hardened aluminosilicate material.

In the case of the anode version then the additional ingredient uses recycled conductive additive to provide conductivity and lowering of the resistivity of the material that allows current to pass to protect steel from corrosion. LoCem® in both forms can be hand-placed, gunned, formed, sprayed and moulded as with any conventional mortar and concrete mix.

## Technical Information

| Property | Value, Unit |
|---|---|
| Compressive strengths | Mix designs up to 60 N/mm$^2$ |
| Flexural strength | 8 N/mm$^2$ |
| Workability | With retarder use from 10mins to 2hours |
| Ultra-low resistivity of anode materials | 2.5-3kohm.cm |
| Fireproof | EN1363-1 (at least 5 hours at 1200C with only 140C heat Y transference at 150mm thick) |

***Note: For more information:*** *https://www.c-probe.co.uk/products-solutions-for-resilience-management-of-corrosion/locem/*

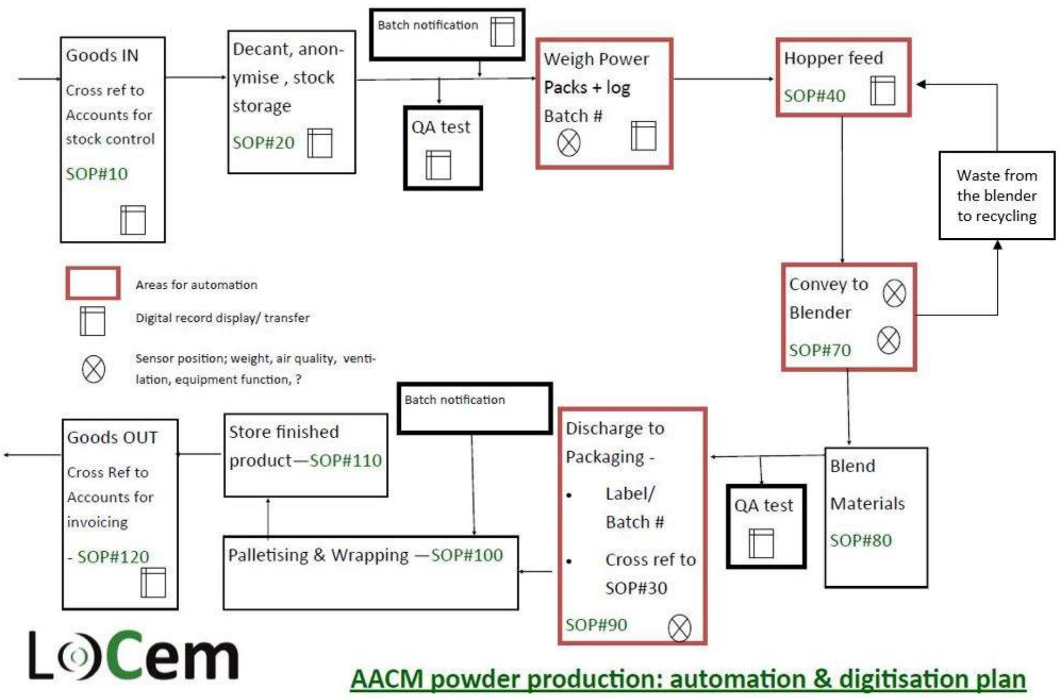
## Main Product Contents

| Material/Chemical Input | % |
|---|---|
| GGBS | 45-50 |
| Silica sand | 25-30 |
| Others | 20-30 |

## Manufacturing Process

1. Goods In receives raw feedstocks from delivery as powder bags (binder components) and within an IBC for the activator (sodium silicate) liquid.
2. Bags are decanted and anonymised within the decant room and placed into numbered tubs. At this point a quality check is undertaken using the inhouse x-ray fluorescence (XRF) equipment to assess consistency of supply with respect to contaminants, such as chloride and heavy metals.
3. Each ingredient is weighed on electronic scales and placed into the hopper at ground level.
4. Once the ingredients are placed in the hopper then they are transferred vertically to the blender using the air transporter (see Figure 14 right).
5. Once in the blender the formulation is shear-mixed for 5 minutes and a visual check made to assess completeness of the blending process. Samples are taken to reassess blend constituents using XRF equipment.
6. On completion of the blending the final product is gravity fed to the automated bagging equipment to packaging, sealing, and labelling.
7. On completion of the packaging the bags are transported to the palletising area using roller conveyors by hand.
8. On palletising the end product is plastic wrapped using a hand-held pallet wrapper and placed in the Goods Out area for despatch.
9. For the activator liquid the sodium silicate (SS) is diluted with water in the proportion 30:70 SS: water.
10. The diluted liquid is dispensed using a peristaltic pump into plastic bottles (see Figure 15 opposite left).
11. If needed, retarder liquid is added to the activator liquid.
12. The bottles are packaged on to the pallets quantified in proportion with the LoCem® powder bags and wrapped for despatch together.

## Process flow diagram



## Construction Installation

LoCem +point installed into bed joints and drill holes within existing building façade by contractor. Bed joint mortar is cut or drilled, cleaned using dust blower, wet down before installing feed wire then +point anode mortar installed.

## Use Information

LoCem® has also been used in reinforced concrete structures, such as car parks, as +chase® where the mortar is placed in cut chases with the deck to protect reinforcement steel. Additionally, it is used in sprayed concrete form as +shot®, using conventional wet and dry spray equipment.

After the installation, no maintenance, refurbishment, and replacement take place therefore no impacts from B1-B5 modules.

## End of Life

The intended use of LoCem® anode mortars, grouts, and concrete are to prolong the lifespan of existing structures by passing protection current through construction materials, such as concrete and masonry, to the steel reinforcement or frames, thereby preventing corrosion. In new construction, LoCem® anode binders can be used in moulded modular form as factory-made components with connectors for direct attachment to reinforcement steel before concrete placement, providing corrosion protection from the outset. When incorporated into precast elements, they can facilitate the re-energizing of the Impressed Current Cathodic Protection (ICCP) system upon reuse, thereby further extending the lifespan of the element.

During end-of-life deconstruction of the entire building using heavy machineries, any LoCem Binder attached to concrete blocks or reinforcement structures will be separated and crushed in the pre-processing sector. Since deconstruction encompasses the entire building, the energy expended in removing the LoCem anode mortar is comparatively negligible in relation to overall demolition.

# Life Cycle Assessment Calculation Rules

## Declared unit description.

1 kg of LoCem® anode binder

## System boundary

This is a cradle-to-gate with options LCA, reporting all production life cycle stages of modules A1 to A3, A4 and A5 (transportation and installation), Use stage (B1-B5), end of life stages C1-C4, and D in accordance with EN 15804:2012+A2:2019 and BRE 2023 Product Category Rules (PN 514 Rev 3.1).

## Data sources, quality, and allocation

The quantity used in the data collection for this EPD is the total quantity of LoCem anode binder manufactured during the data collection period (01/01/21-31/12/21). In addition to the LoCem binder, other products are manufactured in the manufacturing site during the data collection period, therefore, allocation to electricity, water consumption, non-production waste, and wastewater discharge is required. This allocation has been based on mass allocation as per the provision to EN 15804 A2. The original data collection form has been used while doing an LCA analysis, there was a no uplift in the given data.

The manufacturing of LoCem anode is through the lean production process so there will be a very low chances of waste from the production and the manufacturer also confirmed that there is no production waste during the data collection period. Secondary data has been obtained for all other upstream and downstream processes that are beyond the control of the manufacturer (i.e., raw material production) from the ecoinvent 3.8 database. All ecoinvent datasets are complete within the context used and conform to the system boundary and the criteria for the exclusion of inputs and outputs, according to the requirements specified in EN15804.

In the raw material input, the manufacturer uses secondary raw materials such as GGBS and fly ash. GGBS is a co-product of steel manufacturing, while fly ash is a co-product of coal production. Therefore, both secondary raw materials are economically allocated.

GGBS has been allocated economically by 2.3%, based on recommendations from "Embodied Carbon of Concrete in Buildings, Part 1: Analysis of Published EPDs" by Jane Anderson and Alice Moncaster, following EN15804 recommendations.

Fly ash is allocated economically using the revenue of 1 kg of fly ash and following the guidance of Shi, X et al. (2021), "Life Cycle Assessment and Impact Correlation Analysis of Fly Ash Geopolymer Concrete.
Specific European datasets have been selected from the ecoinvent LCI for this LCA.

| ISO14044 guidance. **Quality Level** | **Geographical representativeness** | **Technical representativeness** | **Time representativeness** |
|---|---|---|---|
| Very Good | Data from area under study. | Data from processes and products under study. Same state of technology applied as defined in goal and scope (i.e., identical technology). | n/a |
| Very Good | n/a | n/a | There is approximately 1-2 years between the Ecoinvent LCI reference year, and the time period for which the LCA was undertaken. |

Specific European datasets have been selected from the ecoinvent LCI for this LCA. Manufacturer uses the national grid electricity and natural gas for production, so therefore the national grid electricity dataset has been used for the LCA modelling (Ecoinvent 3.8). The GWP carbon footprint for using 1 kWh of electricity, GB kwh is 0.3122 in kgCO2e/kWh and for the UK natural has carbon footprint for using 1 kWh is 0.232 kgCO2eq. The quality level of time representativeness is also Very Good as the background LCI datasets are based on ecoinvent v3.8 which was compiled in 2021. Therefore, there is less than 5 years between the ecoinvent LCI reference year and the time period for which the LCA was undertaken

## Cut-off criteria

All raw materials and energy input to the manufacturing process have been included, except for direct emissions to air, water, and soil, which are not measured. The inventory process in this LCA includes all data related to raw material, packaging material and consumable items. Process energy, water use, and discharge are included, except the production waste.

## LCA Results

(MND = module not declared; MNR = module not relevant; INA = indicator not assessed; AGG = aggregated)

**Parameters describing environmental impacts**

| | | | GWP-total | GWP-fossil | GWP-biogenic | GWP-luluc | ODP | AP | EP-freshwater |
|---|---|---|---|---|---|---|---|---|---|
| | | | kg $CO_2$ eq | kg $CO_2$ eq | kg $CO_2$ eq | kg $CO_2$ eq | kg CFC11 eq | mol $H^+$ eq | kg $(PO_4)^{3-}$ eq |
| Product stage | Raw material supply | A1 | 1.91E-01 | 1.89E-01 | 1.48E-03 | 3.52E-04 | 3.98E-08 | 1.01E-03 | 7.15E-05 |
| | Transport | A2 | 2.12E-02 | 2.11E-02 | 2.75E-05 | 9.91E-06 | 4.75E-09 | 9.59E-05 | 1.92E-06 |
| | Manufacturing | A3 | 8.21E-03 | 5.10E-02 | -4.29E-02 | 7.34E-05 | 2.07E-09 | 2.16E-04 | 1.40E-05 |
| | Total | A1-3 | 2.20E-01 | 2.61E-01 | -4.14E-02 | 4.36E-04 | 4.66E-08 | 1.32E-03 | 8.74E-05 |
| Construction process stage | Transport | A4 | 4.38E-02 | 4.37E-02 | 3.73E-05 | 1.72E-05 | 1.01E-08 | 1.77E-04 | 2.82E-06 |
| | Construction | A5 | 5.11E-01 | 5.09E-01 | 8.94E-04 | 8.56E-04 | 6.50E-08 | 3.96E-03 | 6.00E-04 |
| Use stage | Use | B1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Maintenance | B2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Repair | B3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Replacement | B4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Refurbishment | B5 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **95% - recycling 5% landfill** | | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 8.32E-03 | 8.31E-03 | 7.08E-06 | 3.26E-06 | 1.92E-09 | 3.37E-05 | 5.35E-07 |
| | Waste processing | C3 | 3.82E-03 | 3.82E-03 | 1.35E-06 | 3.81E-07 | 8.16E-10 | 3.97E-05 | 1.18E-07 |
| | Disposal | C4 | 2.64E-04 | 2.63E-04 | 2.61E-07 | 2.49E-07 | 1.07E-10 | 2.48E-06 | 2.41E-08 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -8.00E-03 | -7.88E-03 | -1.02E-04 | -1.11E-05 | -6.36E-10 | -5.07E-05 | -4.29E-06 |
| **100% - Landfill** | | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 8.32E-03 | 8.31E-03 | 7.08E-06 | 3.26E-06 | 1.92E-09 | 3.37E-05 | 5.35E-07 |
| | Waste processing | C3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Disposal | C4 | 5.28E-03 | 5.27E-03 | 5.22E-06 | 4.97E-06 | 2.13E-09 | 4.95E-05 | 4.82E-07 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

GWP-total = Global warming potential, total;
GWP-fossil = Global warming potential, fossil;
GWP-biogenic = Global warming potential, biogenic;
GWP-luluc = Global warming potential, land use and land use change;

ODP = Depletion potential of the stratospheric ozone layer;
AP = Acidification potential, accumulated exceedance; and
EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment

## LCA Results (continued)

(MND = module not declared; MNR = module not relevant; INA = indicator not assessed; AGG = aggregated)

| Parameters describing environmental impacts | | | EP-marine | EP-terrestrial | POCP | ADP-mineral &metals | ADP-fossil | WDP | PM |
|---|---|---|---|---|---|---|---|---|---|
| | | | kg N eq | mol N eq | kg NMVOC eq | kg Sb eq | MJ, net calorific value | $m^3$ world eq deprived | disease incidence |
| Product stage | Raw material supply | A1 | 1.89E-04 | 2.06E-03 | 6.96E-04 | 2.06E-06 | 1.95E+00 | 2.04E+00 | 1.13E-08 |
| | Transport | A2 | 2.89E-05 | 3.17E-04 | 9.94E-05 | 1.51E-07 | 3.18E-01 | 1.71E-03 | 1.97E-09 |
| | Manufacturing | A3 | 4.58E-05 | 4.71E-04 | 2.12E-04 | 3.21E-07 | 1.50E+00 | 3.72E-02 | 2.91E-09 |
| | Total | A1-3 | 2.64E-04 | 2.85E-03 | 1.01E-03 | 2.53E-06 | 3.77E+00 | 2.08E+00 | 1.62E-08 |
| Construction process stage | Transport | A4 | 5.34E-05 | 5.84E-04 | 1.79E-04 | 1.52E-07 | 6.61E-01 | 2.97E-03 | 3.77E-09 |
| | Construction | A5 | 6.90E-04 | 7.53E-03 | 2.12E-03 | 1.56E-04 | 6.64E+00 | 2.35E-01 | 3.10E-08 |
| Use stage | Use | B1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Maintenance | B2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Repair | B3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Replacement | B4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Refurbishment | B5 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **95% - recycling 5% landfill** | | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 1.02E-05 | 1.11E-04 | 3.40E-05 | 2.89E-08 | 1.26E-01 | 5.65E-04 | 7.17E-10 |
| | Waste processing | C3 | 1.76E-05 | 1.92E-04 | 5.29E-05 | 1.96E-09 | 5.24E-02 | 1.21E-04 | 8.13E-09 |
| | Disposal | C4 | 8.61E-07 | 9.42E-06 | 2.74E-06 | 6.01E-10 | 7.35E-03 | 3.37E-04 | 4.99E-11 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -1.17E-05 | -1.41E-04 | -3.63E-05 | -7.45E-08 | -1.16E-01 | -1.52E-02 | -6.41E-10 |
| **100% - Landfill** | | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 1.02E-05 | 1.11E-04 | 3.40E-05 | 2.89E-08 | 1.26E-01 | 5.65E-04 | 7.17E-10 |
| | Waste processing | C3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Disposal | C4 | 1.72E-05 | 1.88E-04 | 5.48E-05 | 1.20E-08 | 1.47E-01 | 6.74E-03 | 9.97E-10 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment;
EP-terrestrial = Eutrophication potential, accumulated exceedance;
POCP = Formation potential of tropospheric ozone;
ADP-mineral&metals = Abiotic depletion potential for non-fossil resources;
ADP-fossil = Depletion potential of the stratospheric ozone layer;
WDP = Water (user) deprivation potential, deprivation-weighted water consumption; and
PM = Particulate matter.

## LCA Results (continued)

(MND = module not declared; MNR = module not relevant; INA = indicator not assessed; AGG = aggregated)

| Parameters describing environmental impacts | | | IRP | ETP-fw | HTP-c | HTP-nc | SQP |
|---|---|---|---|---|---|---|---|
| | | | kBq $U^{235}$ eq | CTUe | CTUh | CTUh | dimensionless |
| Product stage | Raw material supply | A1 | 1.20E-02 | 5.21E+00 | 4.38E-10 | 3.97E-09 | 1.25E+00 |
| | Transport | A2 | 1.75E-03 | 2.70E-01 | 1.64E-11 | 3.07E-10 | 1.97E-01 |
| | Manufacturing | A3 | 6.79E-03 | 5.26E-01 | 7.29E-11 | 5.00E-10 | 3.91E+00 |
| | Total | A1-3 | 2.05E-02 | 6.01E+00 | 5.27E-10 | 4.77E-09 | 5.36E+00 |
| Construction process stage | Transport | A4 | 3.40E-03 | 5.16E-01 | 1.67E-11 | 5.41E-10 | 4.54E-01 |
| | Construction | A5 | 5.84E-02 | 4.21E+01 | 7.38E-10 | 2.55E-08 | 3.26E+00 |
| Use stage | Use | B1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Maintenance | B2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Repair | B3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Replacement | B4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Refurbishment | B5 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **95% - recycling 5% landfill** | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 6.46E-04 | 9.81E-02 | 3.18E-12 | 1.03E-10 | 8.63E-02 |
| | Waste processing | C3 | 2.36E-04 | 3.06E-02 | 1.19E-12 | 2.22E-11 | 6.67E-03 |
| | Disposal | C4 | 3.27E-05 | 4.64E-03 | 1.18E-13 | 3.05E-12 | 1.54E-02 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -1.80E-03 | -1.34E-01 | -7.81E-12 | -1.41E-10 | -1.07E-01 |
| **100% - Landfill** | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 6.46E-04 | 9.81E-02 | 3.18E-12 | 1.03E-10 | 8.63E-02 |
| | Waste processing | C3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Disposal | C4 | 6.53E-04 | 9.29E-02 | 2.36E-12 | 6.11E-11 | 3.09E-01 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

IRP = Potential human exposure efficiency relative to U235;
ETP-fw = Potential comparative toxic unit for ecosystems;
HTP-c = Potential comparative toxic unit for humans;
HTP-nc = Potential comparative toxic unit for humans; and
SQP = Potential soil quality index.

## LCA Results (continued)

(MND = module not declared; MNR = module not relevant; INA = indicator not assessed; AGG = aggregated)

| Parameters describing resource use, primary energy | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | PERE | PERM | PERT | PENRE | PENRM | PENRT |
| | | | MJ | MJ | MJ | MJ | MJ | MJ |
| Product stage | Raw material supply | A1 | 1.42E-01 | 0.00E+00 | 1.42E-01 | 1.96E+00 | 2.01E-01 | 2.16E+00 |
| | Transport | A2 | 5.80E-03 | 0.00E+00 | 5.80E-03 | 3.12E-01 | 0.00E+00 | 3.12E-01 |
| | Manufacturing | A3 | 3.48E-01 | 4.13E-01 | 7.61E-01 | 7.48E-01 | 7.41E-01 | 1.49E+00 |
| | Total | A1-3 | 4.97E-01 | 4.13E-01 | 9.09E-01 | 3.02E+00 | 9.42E-01 | 3.96E+00 |
| Construction process stage | Transport | A4 | 9.31E-03 | 0.00E+00 | 9.31E-03 | 6.49E-01 | 0.00E+00 | 6.49E-01 |
| | Construction | A5 | 6.71E-01 | 4.13E-05 | 6.71E-01 | 5.93E+00 | 9.42E-05 | 5.93E+00 |
| Use stage | Use | B1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Maintenance | B2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Repair | B3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Replacement | B4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Refurbishment | B5 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **95% - recycling 5% landfill** | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 1.77E-03 | 0.00E+00 | 1.77E-03 | 1.23E-01 | 0.00E+00 | 1.23E-01 |
| | Waste processing | C3 | 2.93E-04 | 0.00E+00 | 2.93E-04 | 5.14E-02 | 0.00E+00 | 5.14E-02 |
| | Disposal | C4 | 6.27E-05 | 0.00E+00 | 6.27E-05 | 7.22E-03 | 0.00E+00 | 7.22E-03 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -1.09E-02 | 0.00E+00 | -1.09E-02 | -1.16E-01 | 0.00E+00 | -1.16E-01 |
| **100% - Landfill** | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 1.77E-03 | 0.00E+00 | 1.77E-03 | 1.23E-01 | 0.00E+00 | 1.23E-01 |
| | Waste processing | C3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Disposal | C4 | 1.25E-03 | 0.00E+00 | 1.25E-03 | 1.44E-01 | 0.00E+00 | 1.44E-01 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

PERE = Use of renewable primary energy excluding renewable primary energy 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 resource

## LCA Results (continued)

(MND = module not declared; MNR = module not relevant; INA = indicator not assessed; AGG = aggregated)

| Parameters describing resource use, secondary materials and fuels, use of water | | | | | | |
|---|---|---|---|---|---|---|
| | | | SM | RSF | NRSF | FW |
| | | | kg | MJ net calorific value | MJ net calorific value | m³ |
| Product stage | Raw material supply | A1 | 2.78E-04 | 3.55E-06 | 0.00E+00 | 2.51E-03 |
| | Transport | A2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.25E-05 |
| | Manufacturing | A3 | 1.58E-03 | 1.27E-10 | 0.00E+00 | 8.86E-04 |
| | Total | A1-3 | 1.86E-03 | 3.55E-06 | 0.00E+00 | 3.44E-03 |
| Construction process stage | Transport | A4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.37E-05 |
| | Construction | A5 | 4.38E-03 | 3.55E-10 | 0.00E+00 | 5.83E-03 |
| Use stage | Use | B1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Maintenance | B2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Repair | B3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Replacement | B4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Refurbishment | B5 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **95% - recycling 5% landfill** | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.40E-05 |
| | Waste processing | C3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.99E-06 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.88E-06 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | -3.58E-04 |
| **100% - Landfill** | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.40E-05 |
| | Waste processing | C3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.58E-04 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

SM = Use of secondary material;
RSF = Use of renewable secondary fuels;
NRSF = Use of non-renewable secondary fuels;
FW = Net use of fresh water

## LCA Results (continued)

(MND = module not declared; MNR = module not relevant; INA = indicator not assessed; AGG = aggregated)

| Other environmental information describing waste categories | | | | | |
|---|---|---|---|---|---|
| | | | HWD | NHWD | RWD |
| | | | kg | kg | kg |
| Product stage | Raw material supply | A1 | 1.84E-02 | 3.59E-01 | 5.10E-06 |
| | Transport | A2 | 4.50E-04 | 8.56E-03 | 6.41E-01 |
| | Manufacturing | A3 | 2.26E-03 | 6.48E-02 | 2.12E-06 |
| | Total | A1-3 | 2.11E-02 | 4.33E-01 | 6.41E-01 |
| Construction process stage | Transport | A4 | 7.29E-04 | 1.29E-02 | 4.47E-06 |
| | Construction | A5 | 5.32E-02 | 1.17E+00 | 5.12E-01 |
| Use stage | Use | B1 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Maintenance | B2 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Repair | B3 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Replacement | B4 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Refurbishment | B5 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **95% - recycling 5% landfill** | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 1.39E-04 | 2.46E-03 | 8.50E-07 |
| | Waste processing | C3 | 6.87E-05 | 4.83E-04 | 3.62E-07 |
| | Disposal | C4 | 7.65E-06 | 1.08E-04 | 4.82E-08 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -6.68E-04 | -2.03E-02 | -5.93E-07 |
| **100% - Landfill** | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 1.39E-04 | 2.46E-03 | 8.50E-07 |
| | Waste processing | C3 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Disposal | C4 | 1.53E-04 | 2.16E-03 | 9.64E-07 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 |

HWD = Hazardous waste disposed;
NHWD = Non-hazardous waste disposed;
RWD = Radioactive waste disposed

## LCA Results (continued)

(MND = module not declared; MNR = module not relevant; INA = indicator not assessed; AGG = aggregated)

| Other environmental information describing output flows – at end of life | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | CRU | MFR | MER | EE | Biogenic carbon (product) | Biogenic carbon (packaging) |
| | | | kg | kg | kg | MJ per energy carrier | kg C | kg C |
| Product stage | Raw material supply | A1 | 0.00E+00 | 5.07E-06 | 7.01E-08 | 1.64E-03 | 0.00E+00 | 0.00E+00 |
| | Transport | A2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Manufacturing | A3 | 0.00E+00 | 5.89E-10 | 7.69E-12 | 2.50E-07 | 0.00E+00 | -2.88E-05 |
| | Total | A1-3 | 0.00E+00 | 5.07E-06 | 7.02E-08 | 1.64E-03 | 0.00E+00 | -2.88E-05 |
| Construction process stage | Transport | A4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Construction | A5 | 0.00E+00 | 1.37E-03 | 2.25E-06 | 1.64E-07 | 0.00E+00 | -2.88E-09 |
| Use stage | Use | B1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Maintenance | B2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Repair | B3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Replacement | B4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Refurbishment | B5 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **95% - recycling 5% landfill** | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Waste processing | C3 | 0.00E+00 | 6.84E-08 | 1.09E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **100% - Landfill** | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Waste processing | C3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

CRU = Components for reuse;
MFR = Materials for recycling
MER = Materials for energy recovery;
EE = Exported Energy

## Scenarios and additional technical information

| Scenarios and additional technical information | | | |
|---|---|---|---|
| Scenario | Parameter | Units | Results |
| A4 – Transport to the building site | Once the LoCem Modular Anode unit manufactured and they will be distributed to the customer site in the UK. In the worst case, the furthest distance has been used to calculate the impacts. | | |
| | Transport mode / Vehicle type | Road transport | 16–32-ton lorry |
| | Manufacturing unit to customer site | km | 263 |
| | Capacity utilisation (incl. empty returns) | % | 49 |
| | Bulk density of transported products | ton/m$^3$ | 24 |
| A5 – Installation in the building | LoCem® binder and activator used for the protection of structural steel in concrete and masonry during the restoration of existing buildings and infrastructure. It can be installed between masonry brick and stone blockwork within bed joints, within chases in reinforced concrete, spray applied as a cementitious anode or as a componentised factory-made modular form attached to steel during new construction. In the production within the data collection, it was used for a transitional-era brick-clad building to protect the internal structural steel frame by installing within the external bed joints.<br><br>The anode mortar system vertically integrates with network control and monitoring electronics, embedded sensors and associated electrical enclosures and wiring to provide a full impressed current cathodic protection (ICCP) system.<br><br>There is a measured design quantity for all components and as such no installation waste. | | |
| | **Ancillary materials used for installation** | **Units** | **Quantities** |
| | Anode feed wire | kg | 0.0006 |
| | Electronics for operation and monitoring | kg | 0.0068 |
| | Embedded corrosion rate probes for monitoring | kg | 0.0028 |
| | Wiring, enclosures, connections | kg | 0.0035 |
| | Sodium silicate solution (Liquid activator) | kg | 0.0651 |
| | Retarder (Liquid activator) | kg | 0.0063 |
| | Water used for mixing | kg | 0.1519 |
| Use Stage B1-B5 | LoCem® has also been used in reinforced concrete structures, such as car parks, as +chase® where the mortar is placed in cut chases with the deck to protect reinforcement steel. Additionally, it is used in sprayed concrete form as +shot®, using conventional wet and dry spray equipment.<br><br>After the installation, no maintenance, refurbishment, and replacement taken place therefore no impacts from B1-B5 modules. | | |

| Scenarios and additional technical information | | | |
|---|---|---|---|
| Scenario | Parameter | Units | Results |
| End of life | At the end-of-life, the entire building undergoes deconstruction using heavy machinery. Due to the inability to separate the binder from the concrete blocks or reinforcement structures, the waste processing involves the entirety of the construction waste. The actual waste processing procedures depend on the availability of recycling sectors around the demolition unit. Therefore, for the end-user preferences, two end of life scenarios has been modelled and included in the results.<br><br>Scenario 1: 95% recycling and 5% landfill (BRE EN15804 A2 PCR 3.1).<br><br>Scenario 2: 100% to Landfill - In this scenario, it is assumed that there is no waste processing site near the deconstruction unit. Therefore, 100% of the recovered waste is sent to landfill without any pre-processing. | | |
| Scenario 1:<br><br>C1 - Deconstruction, Demolition<br><br>95% to Recycling and 5% to Landfill | LoCem Binder attached to any concrete blocks or reinforcement structures will be sent to the pre-processing sector for separation and crushing. The deconstruction takes place over the entire building, so the energy attributed to removing the LoCem anode mortar compared to the overall demolition will be effectively negligible. Therefore, no impacts are attributable to module C1. | | |
| Scenario 2:<br><br>C1 - Deconstruction, Demolition<br><br>100% Landfill | LoCem anode binder attached to any concrete blocks or reinforcement structures will be recovered for the waste processing at the deconstruction site. In this scenario, it is assumed that recovered structures associated with Binders will be sent to landfilling without pre-processing. As buildings, roads, bridges, and other concrete structures age or become obsolete, they often need to be demolished or renovated. During this process, the concrete is broken down into rubble, which may be deemed unsuitable for reuse due to contamination, structural integrity issues, or lack of demand. | | |
| C2- Transportation | 50km by road has been modelled for module C2 as a typical distance from the demolition site to the recycling/landfill unit. However, end-users of the EPD can use this information to calculate the impacts of a bespoke transport distance for module C2 if required. | Litres per km | 0.227 |
| | Distance: Deconstruction unit to pre-processing unit | km | 50 |
| | Transportation | Road transport | Lorry, 16-32 metric ton |
| Scenario 1:<br>C3- Pre-processing<br><br>95% to Recycling and 5% to Landfill | In the pre-processing sector, the separation process involves crushing the recovered concrete, thereby removing metals such as rebar and other components and recycling them separately. The concrete waste will be crushed, and it can be used for road gravel, revetments, retaining walls, landscaping gravel, or raw material for new concrete. Large pieces can be used as bricks or slabs or incorporated with new concrete into structures. As per BRE EN15804 A2 PCR 3.1 end of life scenario for the structure concrete, 95% of the concrete waste will be recycled and 5% sent to landfill. The sorting and separation and crushing processes have not been included in module C3 because it is assumed to be very small and are effectively negligible. | | |
| | 95% of LoCem binder with concrete waste to recycling | kg | 0.95 |
| Scenario 2: 100% Landfill | 100% sent to landfill no preprocessing | | |
| Scenario 1:<br>C4 – Disposal | The recovered concrete waste is sent for recycling, which is assumed to be 95%, while a small portion is assumed to be unrecoverable and is considered to be sent to landfills at 5%. | | |
| | 5% Unrecovered LoCem Binder with concrete waste to landfill | kg | 0.05 |
| Scenario 2: C4 – Disposal | 100% product sent to Landfilling | kg | 1 |
| Module D for scenario 1 | Recovered concrete blocks with the LoCem Binder will be recycled used according to the need. It is assumed that there is a 100% recycling yield from the recycling process | | |

## Interpretation of results

The manufacture of raw materials exerts the greatest influence across all impact categories. Among the total mass of input materials, GGBS accounts for 50%, silica sand for 31%, and the remaining materials collectively make up 0-20% of the total consumption.

In the analysis of environmental impact categories, GGBS contributes the most to the impacts, followed by sodium hydroxide, which has the most impact on the ecosystem.

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