Service Carbon Footprint

carbon footprint

Service Carbon Footprint: Life Cycle Assessment Report for Geobear

A comparison of the standard Geobear Geopolymer Injection service vs a traditional Piled Raft

geobear

ORIGINAL FOUNDER OF URETEK SOLUTIONS

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Executive Summary

This executive summary provides an overview analysis of the greenhouse gas emissions associated with the Geobear Geopolymer Injection service and a traditional Piled Raft method. This assessment focuses on the embodied raw material emissions, the transport of these materials, the manufacture/processing, distribution and disposal of the two services.

The determined scenario for both services for this study is defined as:

A UK domestic project [1]

Geobear aims to encourage its customers to be more sustainable when it comes to subsidence problems, Geopolymer injection below the existing foundations to improve ground strength will avoid excavation and save emissions.

Geobear Geopolymer Injection uses a two-part Geopolymer, and steel injection tubes to inject the Geopolymer[2]. The raw material transport is modelled based on an average supply distance by sea freight and truck to site. The emissions from the fuels used on site were calculated based on the typical machinery fuel consumption. This includes the transport to and from the site as well as the red diesel fuel use on-site. The two-part Geopolymer remains in the soil following the end of the project, however the steel is removed where possible and any Geopolymer wastage from testing is taken back to the depot for disposal. Disposal emissions for the steel and Geopolymer were therefore based solely on the transport of the materials.

The comparable traditional method was modelled as using concrete, steel casing for piles, and steel reinforcement. The piles and steel reinforcements, were sourced from within 20 miles of the site, the steel casings for the piles were assumed to be from the 'contractors' yard', modelled the same as the Geopolymer method. The traditional method uses substantially more steel for reinforcement and requires concrete. The emissions calculation includes the transport of two skips to site for the waste generated when removing the original slab.

The following table shows the percentage emissions breakdown for the assessed Geobear Geopolymer Injection service (Annex A):

Process	Emissions	
	$kgCO_2e$	Percentage
Raw materials - embodied	2,184.38	80.1%
Raw materials transport (excluding materials transported by labourers)	46.04	1.7%
Implementation Fuels	169.71	6.2%
Travel to and from site (including materials transported by labourers)	327.34	12.0%
Disposal[3]	-	0%
Total emissions from the project (33 injection points)	**2,727.48**	**100%**
Average emissions per injection point	**82.65**	**100%**

[1] This covers a project completed by Geobear, and includes 33 Geopolymer injection points.
[2] Both the Geopolymer and Hardener formula and reagent are protected.
[3] All waste is transported back with the labourers to the depot. This is therefore covered within the travel to and from site.

The breakdown of life cycle carbon emissions for the Geobear Geopolymer Injection service and the comparison traditional method are shown in the following table:

Process	Traditional	Geobear
	$kgCO_2e$	$kgCO_2e$
Raw materials - embodied	4,055.57	2,184.38
Raw materials transport (excluding materials transported by labourers)	29.42	46.04
Implementation Fuels (Diesel)	1,206.85	169.71
Travel to and from site (including materials transported by labourers)	327.34	327.34
Disposal	186.64	-[4]
Total	**5,805.83**	**2,727.48**

The carbon footprint of the Geobear Geopolymer Injection service produces 53.02% less emissions than the traditional method.

It should also be noted the Geopolymer service also avoids a number of typical additional projects including, new floor screed/insulation, skirting board repairs and cleaning requirements for driveways/landscaping. This is as a result of the process not requiring the excavation of the existing ground.

Geobear has achieved **Carbon Assessed Standard** by completing this project. This shows this service has lower carbon emissions than the traditional method. To provide additional environmental savings and benefits, Geobear could consider supporting carbon offset projects, to mitigate the services unavoidable emissions. This will also allow the use of our **Carbon Neutral Standard** in relation to its client's projects.

[4] All waste is transported back with the labourers to the depot.

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Quality Control

Report issue number:	1.4
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1. Introduction

1.1 Scope of this Assessment

The aim of this assessment is to demonstrate the carbon footprint of the Geobear Geopolymer Injection service and to compare it against a traditional method of repairing domestic subsidence. This is the first assessment Geobear has completed and will be used to demonstrate to their clients the environmental credentials of their services and to differentiate their service in an increasingly competitive marketplace.

Carbon emissions for the service assessed in this report include those derived from the extraction and processing of virgin raw materials, transport of raw materials and on-site construction vehicles to the site, the fuels used on site by the construction vehicles, and disposal.

1.2 What is a Product Life Cycle Assessment (LCA)?

Product (service) LCA is the assessment of the environmental impacts of a service during its life cycle. It incorporates the analysis of raw materials, manufacture, transport and disposal. LCA can evaluate several environmental impacts (air pollution, ozone layer depletion, climate change, etc.) or focus on a single impact (e.g. climate change). When only climate change is considered, it is called service carbon footprint or carbon LCA.

The service carbon footprint detailed in this report is a *Cradle-to-Gate* carbon LCA.

1.3 How is the service carbon footprint calculated?

The service carbon footprint is derived from a combination of activity data provided by Geobear and from publicly available sources (primary data), and emission factors extracted from internationally recognised metrics, greenhouse gas (GHG), activity data is then multiplied by GHG emission factors to produce carbon metrics.

To guarantee transparency and reproducibility, the emission factors used in this report are shown in Annex 1 detailing the exact name of the emission factor as it appears on its respective database. Material emissions factors are sourced either from EcoInvent's database (v3.7.1), ICE v3.0 (2019), or the UK Government (BEIS, 2020). All EcoInvent factors account for all processes during the production of raw materials and all processes.

1.4 Abbreviations

CO_2e	Carbon Dioxide Equivalent
Defra	Department of Environment, Food and Rural Affairs
GHG	Greenhouse Gases
kg	Kilogrammes
km	Kilometres
kWh	Kilowatt Hours
LCA	Life Cycle Assessment

2. Service overview

2.1 Geobear Geopolymer Injection service

Geobear have teams and offices across the UK and in Ireland. Geobear aims to encourage its customers to be more sustainable when it comes to subsidence problems, through Geopolymer injection below the existing foundations to improve ground strength. This is an alternative to the traditional Piled Raft method that requires a significant amount of steel and concrete which both have large CO_2e emissions and subsequent logistical, implementation and disposal emissions.

The Geopolymer Injection service provided by Geobear injects a two-part Geopolymer below the existing foundations to enhance and improve the strength of the ground. This is injected through steel tubes, through hand drilled 16mm holes, at 1-metre centers beneath load-bearing walls or floors.
The sourcing of the raw materials was all calculated based on the distance from the source of materials to the contractor's yard. Therefore, within this assessment, an average supply distance of 148 miles was used for the transport to site.

Once the materials and machinery are transported to site, the machinery is used to drill and inject the Geopolymer. The only waste materials are the steel and small amounts of Geopolymer used in testing which are returned to the depot with the laborers. Table 1 below details the individual materials:

Table 1: Overview of all raw material used to produce a Geopolymer Injection service

Material ID	Material (kg)	Percentage of total weight
Part A- Hardener	337.79	43.80%
Part B- Polymer	250.21	32.45%
Steel Injection Tubes	183.15	23.75%
Grand Total	771.15	100%

2.2 Traditional method (Piled Raft)

For the comparison, a traditional method of a Piled Raft was used to compare and show carbon savings. The traditional method does not use any polymers, instead this method uses premixed concrete with steel as reinforcements. The existing floor slab is excavated with a large quantity being removed in waste skips. This excavation requires significantly more fuel, as there is more time and machinery required. The excavated area is then reinforced with piles and needles and filled with concrete. Within this assessment, the emissions associated with the raw materials, transport, production and disposal of the traditional method is modelled based on standard distances and weights for a similar scale project.

Due to a lack of data, the transport of the raw materials and the service distribution for the traditional method was modelled as less than 20 miles. As these materials are typically sourced locally with the transport to site equal to the Geobear method, ensuring that the results are not biased towards either service.

Disposal of materials from the implementation state is modelled based on the transport of the skip to and from site due to the exact disposal or reuse scenario being unknown. This has been calculated based on a UK average laden lorry travelling to the contractor's site bringing the two skips and two lorries to collect the full skips.

Table 2 details the individual components and their materials used to produce the traditional method.

Table 2: Overview of all raw material used to produce a traditional method

Raw material	Material (kg)	Percentage
Ready Mixed Concrete	14,712.00	92.54%
Steel Casings for Piles	552.00	3.47%
Steel reinforcement (needles)	369.94	2.33%
Steel reinforcement (piles)	264.00	1.66%
Grand Total	15,897.94	**100%**

3. Accuracy of the carbon footprint LCA calculation

The accuracy of the overall carbon footprint calculations for the Geobear Geopolymer Injection service (Table 3) is very good as the majority of the data used in the calculation is primary data or modelled based on past experience and industry standards submitted by Geobear. The accuracy of the data for the comparison traditional method (Table 4) was modelled due to lack of primary data. Similar models were used for both service methods to avoid bias.

Table 3: Source data and calculation accuracy for the Geobear Geopolymer Injection service

Dataset	Source of data and comments	Accuracy
Raw materials Embodied material emissions and processes	Individual component weights and material types provided by Geobear, based on the amount of weight of material needed for the assessed project.	Very Good
Raw materials Transport (excluding materials transported by labourers)	Calculated based on the supplier details provided by Geobear.	Very Good
Travel to and from site Transport (including materials transported by labourers)	Modelled based on average distance from Geobear contractors' site to project site.	Modelled
Implementation Fuels (Diesel)	Calculated based on red diesel usage for a weeks' worth of projects apportioned to the active minutes recorded on technicians' timesheets.	Good
Disposal	This is included within travel from site.	Modelled

Table 4: Source data and calculation accuracy for the traditional method

Dataset	Source of data and comments	Accuracy
Raw materials Embodied material emissions and processes	Individual component weights and material types provided by Geobear based on industry experience.	Modelled
Raw materials Transport (excluding materials transported by labourers)	Modelled based on industry standard distances and vehicle types.	Modelled
Travel to and from site Transport (including materials transported by labourers)	Modelled based on industry standard distances and vehicle type data provided by Geobear.	Modelled
Implementation Fuels (Diesel)	Fuels and quantities provided by Geobear based on industry experience.	Modelled
Disposal	Waste Skip details provided by Geobear based on standard distances and vehicle types.	Modelled

4. Carbon Footprint LCA Results

4.1 Embodied emissions from raw materials

Embodied emissions have been calculated by multiplying the mass of each material by the correspondent carbon emission factor (Table 5). The emission factors used typically include, for each material: the extraction of the raw materials they are made of, their transportation, processing, distribution and disposal. The emissions from the Geopolymer and Hardener[5] (the two components which are combined to form the injected Geopolymer), have been apportioned based on the recorded combined weight and standard ratio. Geobear has provided material safety data sheet (MSDS) for both the Geopolymers and Hardeners, to allow for sourcing of the emissions factors based on the chemical composition.

Table 5: Embodied GHG emissions per service

Method	Raw material	Material in final product (kg)	Embodied ($kgCO_2e$)
Geopolymer	Part A- Hardener	337.79	932.300
	Part B- Polymer	250.21	861.973
	Steel Injection Tubes	183.15	390.110
Total		771.15	2,184.38
Traditional	Ready Mixed Concrete	14,712.00	1,938.437
	Steel Casings for Piles	552.00	855.600
	Steel reinforcement (needles)	369.94	736.175
	Steel reinforcement (piles)	264.00	525.360
Total		15,897.94	4,055.572

4.2 Emissions from transport of raw materials (excluding materials transported by labourers)

The emissions associated with transport reflect the mass of each component, the mode of transport and the distance travelled. These were calculated based on Geobear's supplier locations. The traditional method was calculated at 18 miles for all raw materials as these materials will be sourced from nearby merchants. This does not include the distances and materials that are transported with the laborers (Section 4.3).

4.3 Emissions from travel to and from site (including materials transported by labourers)

Includes two HGVs and two vans, calculated to include transport to and from site for both scenarios. These carry the materials that are coming from the construction site, the technicians and the welfare

[5] Geopolymer and hardener are protected.

facilities. This includes the steel casings for the traditional project and the full materials for the Geobear project.

Due to data and site trips not being available for the traditional project it has been modelled the same as the Geopolymer injection project although it should be noted, the traditional method could take 3 to 4 weeks to remove the slab, pile and install the new slab. This will therefore mean the traditional project is likely to have higher emissions due to the laborer transport typically taking 28 more trips over the project time.

4.4 Implementation fuel use

The fuel use is significantly higher for the traditional method due to the increased need to excavate the site. This is as a result of 15 working days typically for this size project, whereas the Geopolymer takes 2 working days.

Geobear has calculated the average diesel litres per minute for their generator (0.0616 L/minute) based on the fuel usage and time of active minutes recorded by their time sheet. As data was only available for one generator, the active minutes of the other generator has been multiplied by this number of litres per minute.

Table 6: GHG emissions per implantation machinery

Method	Raw material	Diesel (l)	Embodied ($kgCO_2e$)
Geopolymer	Generators	63.14	169.71
Geopolymer Total		63.14	169.71
Traditional	Drop Hammer Piling Rig	352.00	946.13
	Stihl Saw	12.00	32.25
	Heavy Breaker w/generator	85.00	228.47
Traditional Total		449.00	1206.85

4.5 Emissions from Disposal

The disposal emissions of the steel used in Geopolymer Injection services only includes the emissions associated with the transportation of the raw materials. As the materials are taken back to the depot alongside the labourers therefore this is accounted for in the travel to and from site.

With the traditional method, the disposal emissions include the transport of all of the waste from the implementation/excavation offsite using two skips. Disposal of materials are modelled based on the transport of the skips to and from site due to the exact disposal or reuse scenario unknown. This has been calculated based on a UK average laden lorry travelling to the contractor's site, bringing the two skips, and two lorries to collect the full skips.

4.6 Summary of results

This report provides an analysis of the greenhouse gas (GHG) emissions associated with a Geobear Geopolymer Injection compared against a traditional service. The total ***cradle to gate*** service life cycle carbon emissions for both services are shown in the following table and chart; split by lifecycle stage.

Table 7: GHG emissions per service

Process	Traditional	Geobear
	$kgCO_2e$	$kgCO_2e$
Raw materials - embodied	4,055.57	2,184.38
Raw materials transport (excluding materials transported by labourers)	29.42	46.04
Implementation Fuels	1,206.85	169.71
Travel to and from site (including materials transported by labourers)	327.34	327.34
Disposal	186.64	-[6]
Total	**5,805.83**	**2,727.48**

As Table 7 shows, based on the agreed scenario, overall, the Geobear Geopolymer Injection has significantly lower emissions when compared to the traditional method (53.02%).

In both the Geobear and traditional services the embodied emissions attributed to the raw material account for the majority of the total emissions. However, as the Geopolymer method uses the Geopolymer to strengthen the existing ground, no concrete is used and on average the traditional method uses 6.5 times more steel, as seen above in Table 5 (section 4.1). This decrease in the amount of concrete and steel required results in 7.25% lower embodied emissions associated with the raw material for the Geopolymer Injection service compared to the traditional. Table 5 also provides a breakdown of the weight of the raw materials used in both methods and the associated embodied emissions; it can be seen that despite the embodied emissions for the Geopolymer being high, the overall emissions are lower due to less materials required.

The key saving can be seen in the diesel required to complete the project. This is due to the Geopolymer only requiring two generators over two days rather than the fuels and machinery needed to break up the existing ground and lay the concrete and steel reinforcements.

The raw materials transport (excluding materials transported by labourers) emissions from the Geopolymer Injection service is higher due to the polymers requiring shipping and increased transport distances. This is largely outweighed by the other emissions savings throughout the service.

The disposal emissions are substantially less for the Geopolymer Injection service, due to the waste being transported back with the labourers. This is possible due to the small waste amounts from the steel tubes and polymer testing. In comparison the traditional method requires two skips to remove the excess materials from the excavation process.

[6] All waste is transported back with the labourers to the depot.

It should also be noted the Geopolymer service also avoids a number of typical additional projects including, new floor screed/insulation, skirting board repairs and cleaning requirements for driveways/landscaping. This is as a result of the process not requiring the excavation of the existing ground.

5. Carbon Footprint Standard

5.1 Brand endorsement

Geobear in conjunction with Carbon Footprint Ltd, has assessed the *cradle to gate* carbon emissions associated with a typical domestic **Geobear Geopolymer Injection service**. By achieving this, Geobear has qualified to use the Carbon Footprint Standard branding. This can be used on all marketing materials, including web site and customer tender documents, to demonstrate your carbon management achievements.

The Carbon Footprint Standard is in recognition of your organisation's commitment to managing your services' carbon emissions.

6. References

1. EcoInvent database v3.7.1 2021, available at http://www.Ecoinvent.org/
2. Guidelines to Defra's Greenhouse Gas (GHG) Conversion Factors for Company Reporting – annexes (June 2013)
3. UK Government GHG Conversion Factors for Company Reporting (August 2020)
4. ICE Database V3.0 – 10 Nov 2019- Inventory of Carbon & Energy (ICE) database

Annex A: Emission Factors

The following table shows the emission factors used for the calculations contained in this report.

Table 8 Emission factors sources

Element	Emissions factor	Comments	Unit	Database
Raw Materials (embodied)				
Part A - Hardener	**2.76**	Supplier specific emissions factor	$kgCO_2e$ per kg material	Eco-Profile 2021
Part B - Polymer	**3.455**	Supplier specific emissions factor		Ecochain 2022
Part A - Hardener	**See Footnote**	EcoInvent 3.7.1		EcoInvent v3.7.1 + ICE v3.0 (2019)
Part B - Polymer	**See Footnote**	EcoInvent 3.7.1		
Tubes – Steel Injection Tubes	**2.13**	ICE v3.0 (2019) -Steel, global seamless tube		
Ready Mixed Concrete	**0.13**	DEFRA - Concrete		
Steel Casings for Piles	**1.55**	ICE v3.0 (2019) - Steel, Section		
Steel reinforcement (piles)	**1.99**	ICE v3.0 (2019) - Steel, Rebar		
Steel reinforcement (needles)	**1.99**	ICE v3.0 (2019) - Steel, Rebar		
Transport				
Container ship	0.0161	Transport of raw materials	$kgCO_2e$ per tonne.km	DEFRA UK 2020
ALL HGVs (average)	0.1065	Transport of raw materials	$kgCO_2e$ per tonne.km	
All HGVs - Average laden	0.86407	Transport to and from site	$kgCO_2e$ per km	
Implementation				
Diesel (Retail)	2.68787	UK Govt – Defra/BEIS 2020	$kgCO_2e$ per litre	Defra/BEIS 2020
Disposal				
All HGVs - Average laden	0.86407	Transport of raw materials	$kgCO_2e$ per km	DEFRA UK 2020

Please note – In accordance with IEA and EcoInvent's End User License Agreement (EULA) emissions factors cannot be presented in the report. A full emissions factor reference has been provided which will allow users with an active EcoInvent account to search for the emissions factor. Please see http://www.Ecoinvent.org/ for further details and to search for factors.