

# Carbon evaluation of Compressed Stabilised Earth Blocks (CSEB) in Nepal

- Max Fordham, United Kingdom, 2021.

## Summary

Based on the study, the **production of 1 kg CSEB** with locally sourced materials **produces 75-78% less CO<sub>2</sub> emissions compared to** the production of **1 kg of a traditional fired brick**. This is still applicable even if the materials have to be transported long distances for the CSEB blocks to be produced as is the case for the site in Darchula.

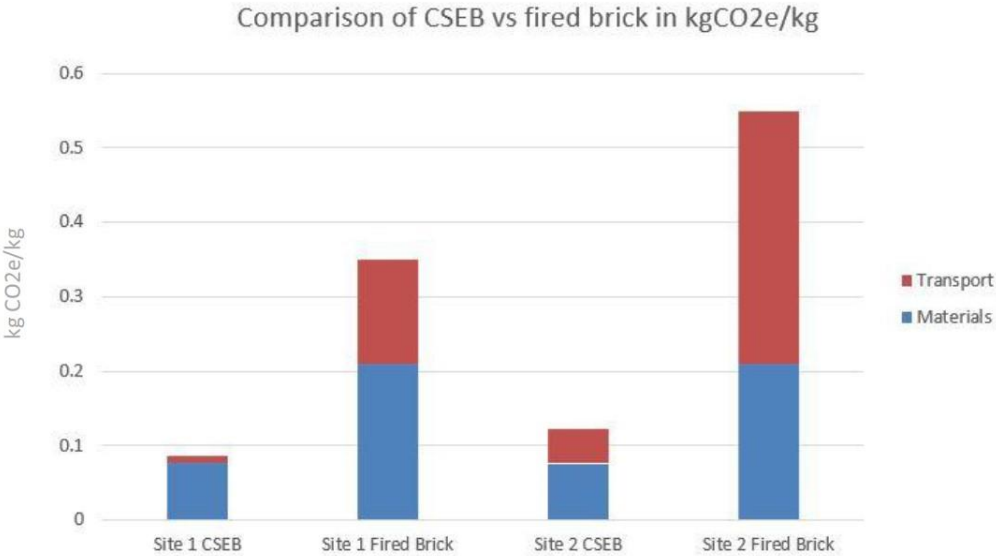


Table 5 Embodied carbon comparison between Site 1 and Site 2 CSEB vs traditional brick

There are also other environmental disadvantages to traditional clay brick method of building, such as coal burning and air-pollution.

*Read the full report in the following pages.*

# **Build Up Nepal - Carbon Evaluation of CSEB Blocks**

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## **Carbon Evaluation of Compressed Stabilised Earth Blocks (CSEB) in Nepal**

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**22.03.2021**

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## MAX FORDHAM LLP TEAM CONTRIBUTORS

Engineer (Initials)	Role
BN	Sustainability Consultant
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## 1.0 EXECUTIVE SUMMARY

Build up Nepal Engineering trains local entrepreneurs to build affordable housing using low-carbon materials such as compressed stabilised earth blocks. To understand if CSEB performs better in terms of carbon emissions, Build-up Nepal Engineering collaborated with Max Fordham to conduct an independent report. The aim of this report is to evaluate the carbon footprint of a typical compressed stabilised earth block (CSEB) and compare the results to those of a traditional fired brick. The report also shows the impact transportation could have on significantly increasing the embodied carbon of a CSEB construction.

Two sites were evaluated – Site 1 (Makwanpur, Palung) and Site 2 (Darchula). The results for Site 1 and 2 showed **0.085 kgCO<sub>2</sub>e/kg** and **0.12 kgCO<sub>2</sub>e/kg** of CSEB respectively (Figure 1). A comparative study was done to evaluate the carbon footprint of a fired clay brick. Data was used for the same two locations, however the emissions associated with the production and transportation of the clay bricks vary. The final result showed the carbon footprint of CSEB brought to site for construction is considerably below the embodied carbon of a fired brick brought to the same site. In the case of Site 1 a clay brick is 0.35 kgCO<sub>2</sub>e/kg and Site 2 is 0.55 kgCO<sub>2</sub>e/kg.

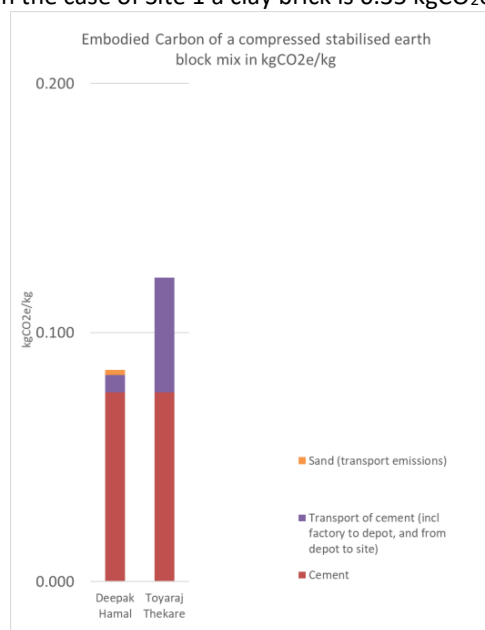


Figure 1 Embodied carbon of CSEB block for two different entrepreneurs in Nepal

The study showed the significance the transport can make to otherwise low-carbon intensive material such as CSEB blocks. As in the case of Site 2, almost half of the emission derive from transportation, even considering transportation of materials for Site 2 also involves the use of carrying animals, such as mules. The impact of the animal however is estimated to be very low.

The results are in CO<sub>2</sub> equivalent. 'Equivalent' stands for other greenhouse gas emissions and environmental impacts associated with material production, such as acidification, pollution, ozone depletion etc. As analysed in Chapter 3 of this assessment, there are additional greenhouse gas emissions associated with the use of diesel and potentially in the growing of food for mules.

Assumptions could influence the results greatly and therefore the assumptions used for this study should be understood as the values associated with a particular product or activity based on the industry's average. As described in Section 3.4 Assumption and limitations, the assumptions used in this study are based on:

- use of environmental product declaration when possible
- emissions from burned fuel for litre per km based on an average heavy-duty transport vehicle in India.

CSEB construction has a higher potential in reducing emissions even further, once cement replacements and more sustainable modes of transportation become available. There are other ecological benefits of constructing using CSEB, as the process of creating each block is not associated with any air-pollution or energy use.

## 2.0 INTRODUCTION

### 2.1 Background and objectives

Traditional construction in Nepal, as well as much of South Asia, is usually associated with locally produced fired clay bricks. The brick kiln industry however is also linked to numerous negative effects on local environmental and social welfare.

Generating highly polluting emissions, directly released in the atmosphere, is one of the largest ecological impacts from firing bricks. Local air-pollution and health effects are also observed as a result of the industry. Non-governmental organisations and local entrepreneurs seek alternative construction materials with lower carbon impact.

Max Fordham was appointed by Build up Nepal Engineering to independently evaluate the embodied carbon of an alternative to traditional clay bricks – compressed stabilised earth blocks or CSEB. Build up Nepal Engineering supports local entrepreneurs homes using CSEB construction. In addition to reducing emissions, Build-up Nepal seeks to provide more resilient buildings to the communities affected after the 2015 earthquakes.

This study is independent from a parallel study done by the Asian Institute of Technology & Management (AITM) in Khumaltar, Lalitpur, Nepal.

### 2.2 Embodied Carbon Stages and EPDs

Calculating the whole lifecycle carbon of a building includes all lifecycle modules (cradle-to-cradle approach) as outlined in the Royal Institution for Chartered Surveyors (RICS) guidelines. This study evaluates the embodied carbon of a CSEB block (in kg and in m<sup>2</sup>), which means it accounts for all emissions associated with the making of a CSEB up until the point of construction or all processes associated with the Cradle-to-gate modules (A1-A3) Figure 2. This is the only way to realistically compare two interchangeable construction materials such as compressed stabilised earth blocks and fired clay bricks 'like for like'.

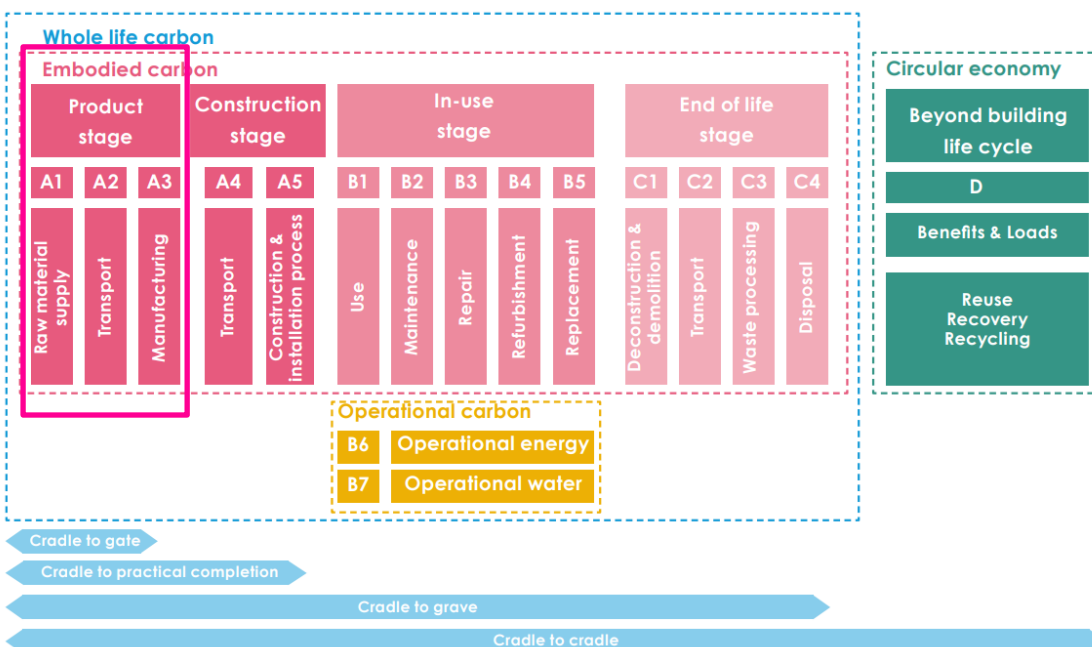


Figure 2 System Boundary: EN 15978:2011 Display of modular information for different stages of the building assessment

An EPD (also referred as an 'ISO Type III Environmental Product Declaration) provides a standardised international way for products to declare the carbon dioxide emissions through a global warming potential (GWP) indicator associated with the product – typically in kgCO<sub>2</sub> equivalent per kg or m<sup>2</sup>. The GWP of mixtures such as concrete for example, are made of the total emissions associated with each of their components (sands, cements, water, aggregates, other binders etc). Each of the components may or may not have an individual EPD. This approach is also used for the calculation of the CSEB introducing EPDs whenever possible (see Chapter 3 Methodology).

### 2.3 Study Area

The scope of the study is focused on the compressed stabilised earth blocks only - all emissions associated with the making of each block. How the blocks are installed on site and any additional material used within the boundary of each site for construction is beyond the scope of the assessment.

The chosen locations are based on the sites where two local Entrepreneurs operate in Nepal. Build up Nepal Engineering supports such Entrepreneurship through equipment for producing CSEB blocks and expertise.

#### Locations

The first local Entrepreneur - Deepak Hamal, is based in Makwanpur, Palung about 50km from Kathmandu (see Figure 3). The area was heavily affected after the 2015 earthquake where 1881 people were displaced from their homes. The area is easily accessible by vehicles.



Figure 3 Google Earth image of Palung area.

The second location is in much more remote area of Darchula, some 700km away from Kathmandu (Figure 4). Some areas are not easily accessible by vehicles, and mules are used for transport of goods and materials.

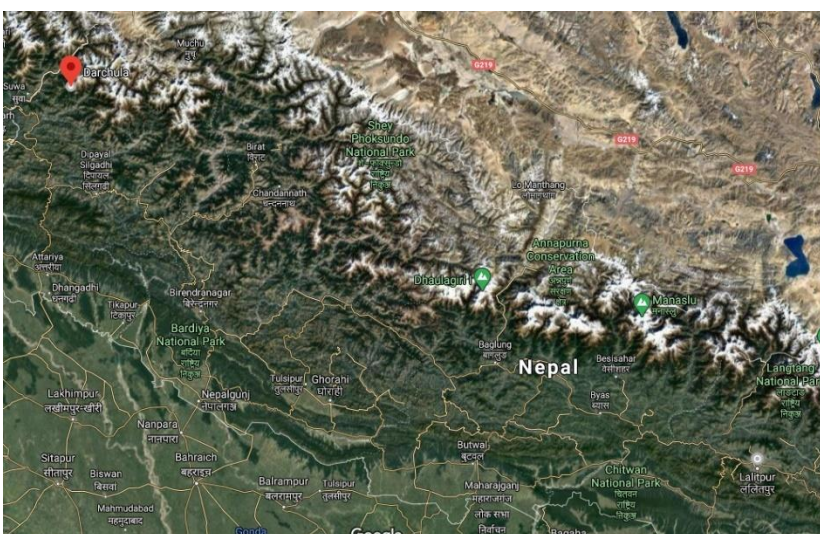


Figure 4 Google Earth image of Darchula in relation to Kathmandu.



## 3.0 METHODOLOGY

### 3.1 Strategic approach

After initial reports review<sup>1</sup>, an internal workshop at Max Fordham was conducted to identify all contributing factors and all the data required to complete such study. The outcome was discussed with Build-up Nepal Engineering and an Information Schedule Request was issued outlining all activities associated with releasing emissions (See Appendix).

Some items were identified as irrelevant in relation to both sites such as emissions from cooking, or additional electricity on site. For the full schedule of information provided by Build up Nepal Engineering, refer to Appendix.

Additional draft review was conducted in February 2021, consolidating additional information on the local fired bricks.

### 3.2 Assumptions and limitations for CSEB calculations

Each CSEB uses soil, sand and cements. The soil is assumed to be very localised, therefore emissions from soil extraction and transportation are not included. The identified direct emissions, as shown on Table 1, derive from transport of cement and sand and the production of the cement. There are some small emissions associated with the food used for the mule.

Table 1. Direct emissions sources

<b>Direct emissions</b>
<b>Energy used for the production of cement</b>
<b>CO<sub>2</sub> emitted from clinker (cement)</b>
<b>Transport of cement (from factory to depot)</b>
<b>Transport of cement (from depot to site)</b>
<b>Transport of sand to site</b>
<b>Emissions from food for mule</b>

Calculating the GWP of a kg of cement could vary significantly from type to type. The cement used for both sites is assumed to be Pozzolanic Portland Cement CEM I type with no cement replacements. The process of cement manufacturing involves electricity and also releases CO<sub>2</sub> from the clinker (the intermediate product which occurs during the process). The emissions from the clinker are considered standard across the industry as the ratio of the cement produced, however emissions associated with the energy use vary. In Nepal hydropower provides almost all of the energy needs for electricity generation on the grid (International Hydropower Association) Therefore the carbon associated with the production of the cement in Nepal is assumed to be equivalent to other hydro powered countries, such as Norway. This assumption assists the data collection, and particularly when using Environmental Product Declarations for products manufactured in Norway.

The calculated embodied carbon of the cement due to manufacturing is considered to be identical for both sites, as the method of manufacturing the cement in both locations in Nepal is assumed to be the same. The weight of 1 bag of cement is assumed to be 50kg.

#### Carbon emissions from transport

The fuel used is known to be diesel, however the vehicles specified -TATA trucks, provide limited information on the fuel consumption per km. Vehicle information was sourced from [www.tatamotors.com](http://www.tatamotors.com), showing capacity and efficiency of the models. According to the Spanish observatory of road freight transport cost report (Observatorio de Costes del Transporte de Mercancías por Carretera) published in October 2019 by the Ministerio de Fomento (Spain's Ministry of Public Works and Transport) a heavy-duty vehicle uses on average 35 litres of diesel every 100km or 0.35l/km. The CO<sub>2</sub> emissions associated with a diesel engine lorry are 2.68 kgCO<sub>2</sub>/km (Table 2).

1. A report from the Asian Institute of Technology & Management, ICIMOD was issued by Build-up Nepal Engineering as a support documentation. Impact from fired bricks on wellbeing, social and environmental consequences is described by the International Bank for Reconstruction and Development's in their Overview of the brick sector in South Asia report



Table 2. Transport emissions table, University of Exeter, Prof.TWDavies

Vehicle type	Kg CO2 per litre
Small petrol car 1.4 litre engine	0.17/km
Medium car (1.4 – 2.1 litres)	0.22/km
Large car	0.27/km
Average petrol car	0.20/km
Small diesel car (>2 litres)	0.12/km
Large car	0.14/km
Average diesel car	0.12/km
Articulated lorry, diesel engine	2.68/km (0.35litres fuel per km)
Rail	0.06 per person per km
Air, short haul ( 500km)	0.18 per person per km
Air, long haul	0.11
Shipping	0.01 per tonne per km

### Mule power calculations

Emissions from animals is less straight forward. Based on the size of the animal, we can assume that it will consume around 1.5% of its weight (Cubritt, Hourse Journal).For the purpose of the study, adult mature donkey was assumed, with an average weight of 180 kg. This is then reviewed against the amount of food required per day and the emissions associated with 1kg of dry hay. Assumptions are also made about the distances a donkey can cover in a day – 40km or 10 hours of walking.

### 3.3 Assumptions and limitations for fired clay brick calculations

Information regarding the location of the kilns and the type and capacity of vehicles used for transportation of the bricks was sourced from Build up Nepal Engineering. The coal used for the kilns is sourced from India. For the purpose of the assessment, the assumed kiln used is a coal fired Hoffmann-type kiln tunnel. The method is considered more traditional in comparison to the more advanced gas fired kilns with waste hot air recycling. Based on this assumption, a generic Environmental Product Declaration was used to produce a fired clay brick – see Appendix for further information. It is assumed that the Global Warming potential for 1kg fired clay brick equals 0.21 kgCO<sub>2</sub>e (stages A1 – A3).

Transportation of the bricks (Stage A4) from the factory to the site is then calculated and added to the total. Full disclosure of the distances, transport type and calculations are shown in the Appendix.

### 3.4 Data collection for CSEB

This report is based on data provided by Build up Nepal Engineering along with supporting research. Information on the cement is sourced from the Environmental Product Declaration of CEM I Standard Cement by Norcem Cement Group (refer to Appendix). For the comparison of CSEB and traditional clay brick, information on emissions per kg of fired brick is adopted from the AITM’s report (Carbon footprint of interlocking Cement Stabilized Earth Brick Houses at Dhungentar, Nuwakot, Nepal).

Values used for the calculation of transport emissions are based on the Fuel consumption standards for heavy-duty vehicles in India report (The International Council for Clean Transportation), as data on local transport emissions is not available. Information about food nutrition for donkeys is based on Horse Journals. All data is received remotely, and no fieldwork data was required or collected.

#### Data sets

There are two sets of data:

- 1 Generic data (applicable to all projects) such as
  - the content of CSEB – cement, sand, soil
  - size - 300 x 150 x 100mm
  - weight. - 7.2 kg/CSEB
  - cement density (1440 kg/m<sup>3</sup>)
  - sand density (2082 kg/m<sup>3</sup>)

- 1 bag of cement – 50kg
- number of CSEB per m2 of façade – 33nr

## 2 Specific data (applicable to either Site 1 or Site 2) as shown on Table 3

Table 3. Information provided by Build up Nepal Engineering for both sites

RICS Stage	Emissions contributors	Entrepreneur Name		
		Deepak Hamal	Toyaraj Thekare	
		Location	SITE 1 (Makwanpur, Palung)	SITE 2 (Darchula, Nepal)
A1 – A3	Mix ratio	Cement %	10	15
		Sand %	60	50
		Soil %	30	35
	Cement	Location source	Hetauda, Nepal	Parsa, Nepal
A1 - A3	Cement	Distance (factory to depot)	73km	976km
		Distance (depot to site)	13km	48km (vehicle) 21km (mule)
		Transportation	Tata LPK 2518 TATA 407	Tata LPK 2518 TATA 408 mule
	Sand	Location source	Naubise, Dhading, Nepal	21 Kms Mule (animal)
A4	CSEB	Transport from factory to site	2km (vehicle)	3km (mule)
A5	Labour	Nr of workers in production	6	4
		Nr or bricks made per day	800	500
	Brick makers Transport to site	Walking	Walking	
	Brick making machine (type and no)	2 DM Manual (no electricity)	1 DM Manual (no electricity)	
	Food	make their own food in the labour camp in the factory	Bring Food from home	
	Wastage materials	Empty Cement bags, Damaged and Broken Bricks	Empty Cement bags, Damaged and Broken Bricks	

### 3.5 Emissions calculations

Quantities were calculated following the provided ratio of cement:sand:soil for each site and generic information for mass, density and associated emissions.

#### 1. Site 1(Deepak Hamal)

Ratio	kg
cement (10%)	0.72
sand (60%)	4.32
soil (30%)	2.16

- Emissions calculations for cement manufacture

Table 4. Breakdown and total emissions from cement manufacturing (Site 1)

Quantities break down	Value	Unit
a bag of cement	50	kg
emissions per kg of cement (EPD data) (A1-A3)	0.8	kg CO <sub>2</sub> /kg
emissions per bag (50kg) of cement (A1-A3)	38	kg CO <sub>2</sub> /bag
nr of bricks required per m <sup>2</sup>	33	nr
total kg of bricks per m <sup>2</sup>	237.6	kg
total kg cement per m <sup>2</sup> (10% of total kg)	23.8	kg
<b>Total cement emissions per block</b>	<b>1</b>	<b>kg CO<sub>2</sub>e</b>
<b>Total cement emissions per kg of CSEB</b>	<b>0.1</b>	<b>kg CO<sub>2</sub>e /kg</b>
<b>Total cement emissions per m<sup>2</sup></b>	<b>18</b>	<b>kg CO<sub>2</sub>e /m<sup>2</sup></b>

- Emissions calculations from transportation of cement

Table 5. Breakdown and total emissions from transporting cement (Site 1)

Emissions break down	Value	Unit
<b>Trip 1 Factory to depot</b>		
% of fuel per 1bag of cement per trip	0.2%	
total km per trip	73	km
fuel consumption per km	0.35	l/km
CO <sub>2</sub> emissions per litre	2.68	kg CO <sub>2</sub> /l
Total emissions per trip	68	kg CO <sub>2</sub>
Total transport contributions per bag of cement	0.16	kg CO <sub>2</sub>
<b>Trip 2 From depot to site</b>		
% of fuel consumed per 1bag of cement per trip	2%	
total km per trip	13	km
fuel consumption per km	0.35	l/km
CO <sub>2</sub> emissions per litre	2.68	kg CO <sub>2</sub> e /l
Total emissions per trip	12	kg CO <sub>2</sub>
Total transport contributions per bag of cement	0.2	kg CO <sub>2</sub>
<b>Total emissions from transportation</b>		
<b>TOTAL transport emissions per bag(50kg) of cement</b>	<b>0.3</b>	<b>kg CO<sub>2</sub>e</b>
<b>Total transport emissions per 1kg block</b>	<b>0.007</b>	<b>kg CO<sub>2</sub>e/kg</b>
<b>Total transport emissions of cement per block</b>	<b>0.05</b>	<b>kg CO<sub>2</sub>e/block</b>
<b>Total transport emissions per m<sup>2</sup></b>	<b>1.65</b>	<b>kg CO<sub>2</sub>e /m<sup>2</sup></b>

- Emissions calculations from transportation of sand

Table 6. Breakdown and total emissions from transporting sand (Site 1)

Emissions break down	Value	Unit
% of fuel consumed per 1m <sup>3</sup> of sand per trip	0.24%	
1m <sup>3</sup> of sand	2082	kg
total km per trip	32	km
fuel consumption per km	0.35	l/km
CO <sub>2</sub> emissions per litre	2.68	kg CO <sub>2</sub> e /l
Total emissions per trip	30	kg CO <sub>2</sub> e
Total transport contributions to 1m <sup>3</sup> sand	3.8	kg CO <sub>2</sub> e
<b>Total emissions per kg of sand</b>	<b>0.002</b>	<b>kg CO<sub>2</sub>e /kg</b>
<b>total emissions of sand per CSEB block</b>	<b>0.008</b>	<b>kg CO<sub>2</sub>e</b>
<b>Total emissions of sand per m<sup>2</sup> facade</b>	<b>0.26</b>	<b>kg CO<sub>2</sub>e /m<sup>2</sup></b>

## 2. Site 2(Toyaraj Thekare)

<b>Ratio</b>	<b>kg</b>
cement (10% )	0.72
sand (50% )	3.6
soil (40% )	2.88

- Emissions calculations for cement manufacture

Table 7. Breakdown and total emissions from cement manufacturing (Site 2)

Quantities break down	Value	Unit
a bag of cement	50	kg
emissions per kg of cement (EPD data) (A1-A3)	0.8	kg CO <sub>2</sub> /kg
emissions per bag (50kg) of cement (A1-A3)	38	kg CO <sub>2</sub> /bag
nr of bricks required per m <sup>2</sup>	33	nr
total kg of bricks per m <sup>2</sup>	237.6	kg
total kg cement per m <sup>2</sup> (10% of total kg)	<b>23.76</b>	kg
<b>Total cement emissions per m<sup>2</sup></b>	<b>18.06</b>	<b>kg CO<sub>2</sub>e/ m<sup>2</sup></b>
<b>Total cement emissions per block</b>	<b>0.55</b>	<b>kgCO<sub>2</sub>e/block</b>
<b>Total cement emissions per kg of CSEB</b>	<b>0.076</b>	<b>kg CO<sub>2</sub>e /kg</b>

- Emissions calculations from transportation of cement

Table 8. Breakdown and total emissions from transportation of cement (Site 2)

Emissions break down	Value	Unit
<b>Trip 1 Factory to depot (vehicle)</b>		
% of fuel per 1bag of cement per trip	0.24%	
total km per trip	1024	km
fuel consumption per km	0.35	l/km
CO <sub>2</sub> emissions per litre	2.68	kg CO <sub>2</sub> e/l
Total emissions per trip	961	kg CO <sub>2</sub> e
Total transport emissions per bag of cement	2.305	kg CO <sub>2</sub> e
<b>Trip 2 From depot to site (mule)</b>		
% of energy used per 1bag of cement per trip	25%	
total days per 21km trip	0.5	km
food consumption per day	2.7	l/km
co2 emissions per kg of hay	0.03	kg CO <sub>2</sub> e /l
Total emissions per trip	0.04	kg CO <sub>2</sub> e
Total transport (mule) contributions to cement	0.01	kg CO <sub>2</sub> e
<b>Total emissions from transportation</b>		
<b>TOTAL transport emissions per 1bag (50kg) of cement</b>	<b>2.315</b>	<b>kg CO<sub>2</sub>e</b>
<b>total transport emissions per 1kg of cement</b>	<b>0.046</b>	<b>kg CO<sub>2</sub>e/kg</b>
<b>total transport emissions of cement per CSEB</b>	<b>0.33</b>	<b>kgCO<sub>2</sub>e/block</b>
<b>Total cement emissions per m<sup>2</sup></b>	<b>11</b>	<b>kg CO<sub>2</sub>e/ m<sup>2</sup></b>

- Emissions calculations from transportation of sand

Table 9. Breakdown and total emissions from transportation of sand (Site 2)

Emissions break down	Value	Unit
% of energy consumed per 1m3 of sand per trip	13%	
total days per 21km trip	0.5	day
food consumption per day	2.7	kg
co2 emissions per kg of hay	0.03	kg CO <sub>2</sub> e /kg
Total emissions per trip	0.04	kg CO <sub>2</sub> e
<b>Total emissions of sand per m<sup>2</sup> facade</b>	<b>0.004</b>	<b>kg CO<sub>2</sub>e /m<sup>2</sup></b>

## 4.0 ANALYSIS AND RESULTS

The study showed that two activities – production of cement and transportation of materials, are the main contributors to embodied carbon of CSEB blocks. Based on the assumptions used for the study, no cement replacements were accounted for. Further input is required from local cement manufacturers on the amount of cement replacements they can provide (such as ground granulated blast-furnace slag or fly ash).

Comparing emissions from CSEB vs fired bricks, ‘like-for-like’ shows the importance of sourcing local materials. If we consider the production of a CSEB block as a standard process which requires energy and releases carbon dioxide in the process, then the embodied carbon from the process is a constant. It therefore matters where materials are sourced from. As shown on Figure 5, the transportation emissions double in the case of Site 2 for the CSEB blocks. The transport emissions associated with CSEB are still considerably lower than the emissions associated with the fired bricks.

The study also showed that the embodied carbon of a fired brick is more than twice higher than that of CSEB. There are also other environmental disadvantages to traditional clay brick method of building, such as coal burning and air-pollution.

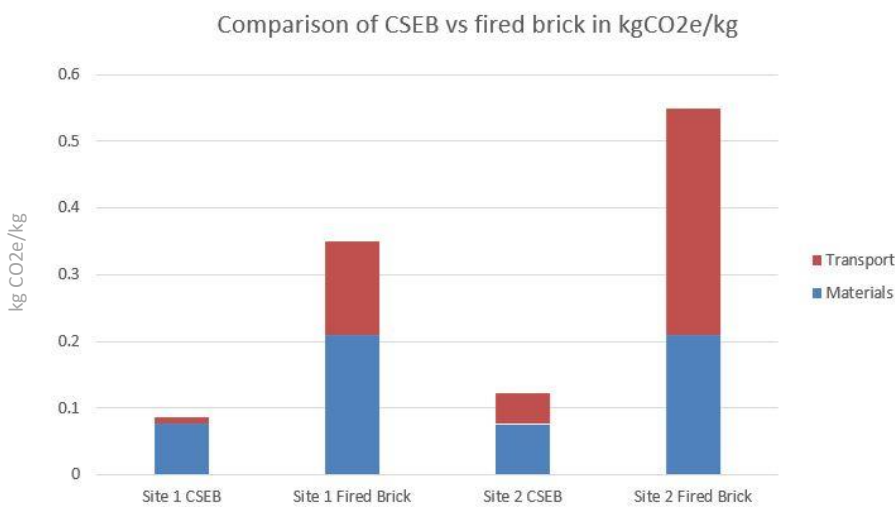


Table 5 Embodied carbon comparison between Site 1 and Site 2 CSEB vs traditional brick

Review of the impact per meter square showed the scale of the benefits in using CSEB blocks as opposed to traditional fired brick – see figure 6.

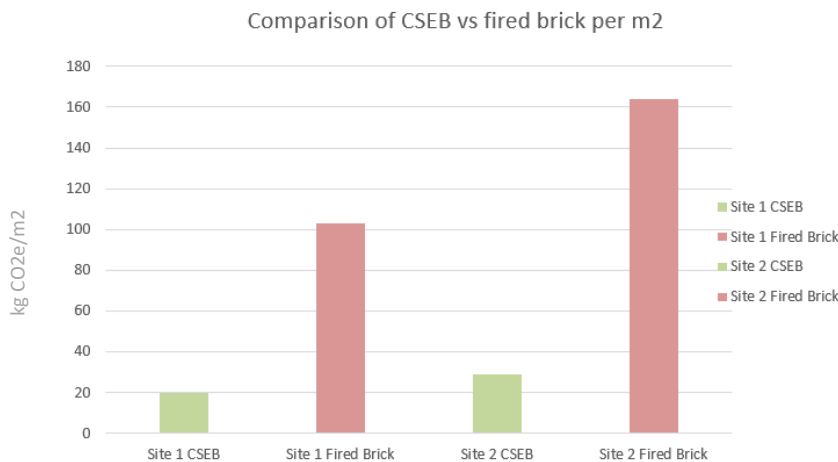


Table 6 Embodied carbon comparison between Site 1 and Site 2 CSEB vs traditional brick

This study does not account for further environmental and well-being aspects associated with the use of CSEB. A further study is recommended on the thermal performance, resilience and material efficiency when constructing with compressed stabilised earth blocks.

### Site 1 Results

Materials for the site are sourced locally, which translates to highest CO<sub>2</sub> emissions resulting from the process of cement manufacture – 0.076 kgCO<sub>2</sub>e/kg (Figure 6) Additionally the emissions from transportation are significant, contributing to 0.01 kgCO<sub>2</sub>e/kg. Transportation of sand is the lowest contributor – 0.002 kgCO<sub>2</sub>e/kg.

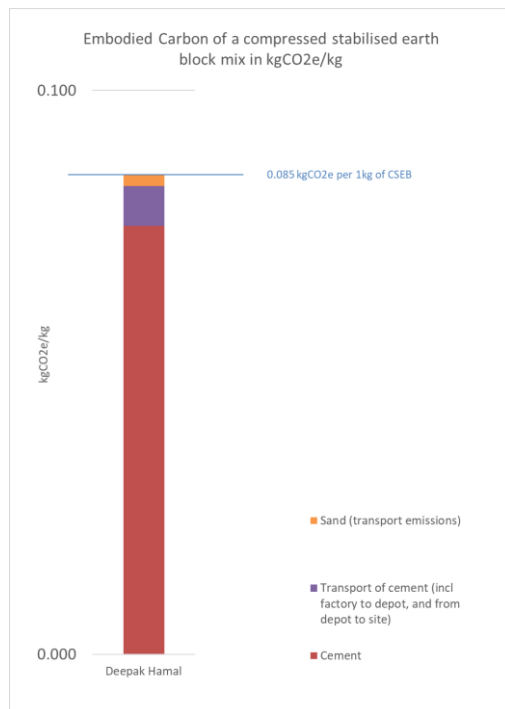


Table 7 Embodied carbon of CSEB in kgCO<sub>2</sub>e/kg produced by Deepak Hamal

The result of evaluating the embodied carbon of a single CSEB block produced in Makwanpur, Palung is shown on Figure 8. The total embodied carbon of one CSEB is 0.61 kgCO<sub>2</sub>e. The proportion of cement in comparison to sand and soil is only 10%, however due to the polluting processes of creating cements, it is the highest contributor, leaving transportation to a small portion to the overall embodied carbon of a single CSEB block.

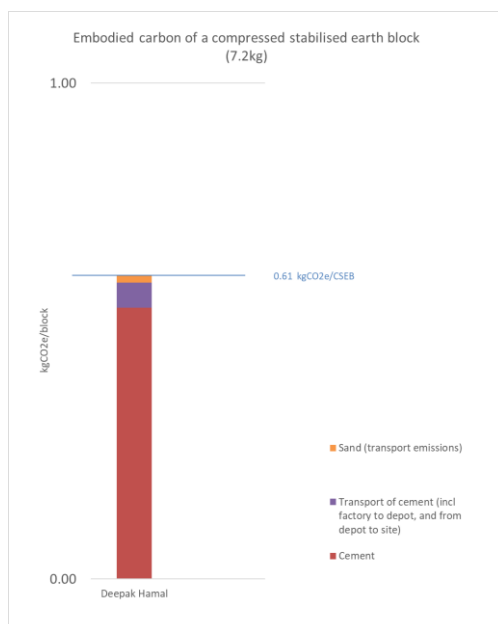


Table 8 Embodied carbon of a CSEB (7.2kg) in kgCO<sub>2</sub>e produced by Deepak Hamal

Available cement replacements (such GGBS or Fly ash) could significantly reduce the embodied carbon of CSEB blocks.



**Site 2 Results**

Materials sourced from further away result in much higher transport emissions and therefore embodied carbon (Figure 9). For kg of CSEB the result is 0.12 kgCO<sub>2</sub>e, which is 1.5 times higher than the emissions associated with Site 1 where materials are sourced within 100km radius.

Emissions are associated mainly with the diesel transport vehicle. The impact of a mule as a source of transportation is considerably lower, resulting in much lower local emissions. Locally sourced sand, transported to site by mule, has a very low embodied carbon (< 0.001 kgCO<sub>2</sub>e). These emissions are not accounted for as they are insignificant.

When reviewed on block per block basis, the embodied carbon is 0.88 kgCO<sub>2</sub>e per block of compressed stabilised earth.

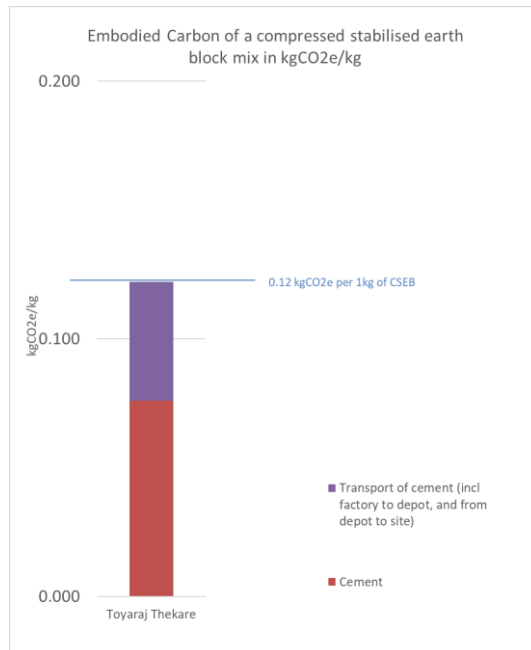


Table 9 Embodied carbon of CSEB in kgCO<sub>2</sub>e/kg produced by Toyaraj Thekare

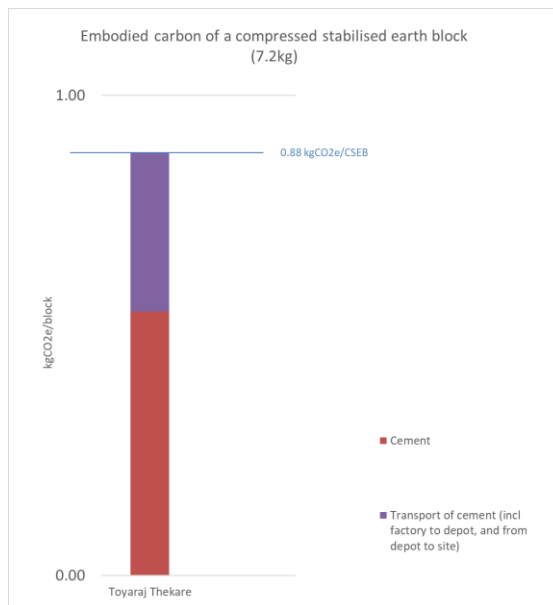


Table 9 Embodied carbon of a CSEB (7.2kg) in kgCO<sub>2</sub>e produced by Toyaraj Thekare

## **Conclusion**

Based on the study, the embodied carbon of a kg CSEB with locally sourced materials is half of the embodied carbon of a traditional fired brick. This is still applicable even if the materials have to be transported long distances for the CSEB blocks to be produced as is the case for the site in Darchula.

Ways to reduce the impact of CSEB construction is through cement replacements or less polluting modes of transportation. Reducing the environmental impact of producing fired brick is less straight forward and includes carbon capture and renewable energy sources. There are however other benefits associated with CSEB construction, such as social value and reduction of air-pollution.



**ENVIRONMENTAL PRODUCT DECLARATION**

ISO 14025 ISO 21930 EN 15804



Eier av deklarasjonen  
Program operatør  
Utgiver  
Deklarasjonens nummer  
Godkjent dato  
Gyldig til

Norcem AS  
Næringslivets Stiftelse for Miljødeklarasjoner  
Næringslivets Stiftelse for Miljødeklarasjoner  
00023N rev1  
16.10.2013  
16.10.2018

**CEM I, Anlegg og Industri/Standard Sement**

Produkt

Norcem AS  
Produsent

**NORCEM**  
HEIDELBERGCEMENT Group



## Generell informasjon

### CEM I, Anlegg og Industri/Standard Sement

Produkt

#### Program operatør:

Næringslivets Stiftelse for Miljødeklarasjoner  
Postboks 5250 Majorstuen, 0303 Oslo  
Tlf: +47 23 08 80 00  
e-post: [post@epd-norge.no](mailto:post@epd-norge.no)

#### Deklarasjon nummer:

00023N rev1

#### Deklarasjonen er basert på PCR:

CEN Standard EN 15804 tjener som kjerne PCR Requirements on an Environmental Product Declaration (EPD) for Cement, Bau-Umwelt

#### Deklarert enhet:

1 tonn sement fra råvareuttak til port

#### Deklarert enhet med opsjon:

#### Funksjonell enhet:

#### Miljødeklarasjonen er utarbeidet av:

Mie Vold




#### Verifikasjon:

Uavhengig verifikasjon av data og annen miljøinformasjon er foretatt etter ISO 14025, 8.1.3.

eksternt   internt

Seniorforsker, Cecilia Askham  
(Uavhengig verifikator godkjent av EPD Norge)

### Norcem AS

Produsent

#### Eier av deklarasjon:

Norcem AS  
Kontakt person: Liv Margrethe Hatlvik Bjerge  
Tlf: +47 22 87 84 38 (Oslo)  
+47 35 57 24 99 (Brevik)  
e-post: [liv.bjerge@norcem.no](mailto:liv.bjerge@norcem.no)

#### Produksjonssted:

Brevik

#### Kvalitet/Miljøsystem:

Miljøstyringssystem ISO 14001-sertifisert (NO-0001003)

#### Org. no.:

NO 934949145 MVA

#### Godkjent dato:

16.10.2013

#### Gyldig til:

16.10.2018

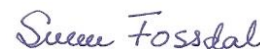
#### Sammenlignbarhet:

EPD av byggevarer er nødvendigvis ikke sammenlignbare hvis de ikke samsvarer med EN 15804

#### Årstall for studien:

2013

Godkjent i tråd med ISO 14025, 8.1.4



Dr. ing Sverre Fossdal  
(Verifikasjonsleder i EPD-Norge)

Deklarert enhet:

1 tonn sement fra råvareuttak til port

Nøkkelindikatorer	Enhet	Anlegg A1 - A3	Industri/Standard A1 - A3	Transport Produksjonssted til sentrallager i Norge
Global oppvarming	kg CO <sub>2</sub> -ekv	758	748	3
Energibruk	MJ	5617	5484	37
Farlige stoffer	*			

\* Produktet inneholder ingen stoffer fra REACH Kandidatliste eller den norske prioritetslisten

## Produkt

### Produktbeskrivelse:

Grå portland sement

### Produktspesifikasjon

Kalkstein fra eget kalkbrudd og gruve, samt dagbrudd i Verdal er viktigste råvaren i tillegg til gips.

Råvaresammensetning i CEM I er som følger:

Materialer	Enhet	Anlegg	Industri/standard
Klinker	kg/DE	909	909
Flyveaske	kg/DE		
Kalkmel	kg/DE	36	36
Gips	kg/DE	49	49
Annet	kg/DE	6	6

### Tekniske data:

Standard Sement (EN 197-1, CEM I 42,5R),

Anlegg Sement (EN 197-1, CEM I 42,5R og NS 3086, CEM I 52,5 N-LA) og

Industri Sement (EN 197-1, CEM I 42,5 R og NS 3086, CEM I 42,5 RR)

Ytterligere informasjon finnes på: Link til Teknisk datablad eller på WEB: <http://www.heidelbergcement.com/no/no/norcem/semmentyper/index.htm>

### Markedsområde:

Norge

### Levetid:

Avhenger av bruksområde

## LCA: Beregningsregler

### Deklarert enhet:

1 tonn sement fra råvareuttak til port

### Systemgrenser:

Fra råvareuttak til marked

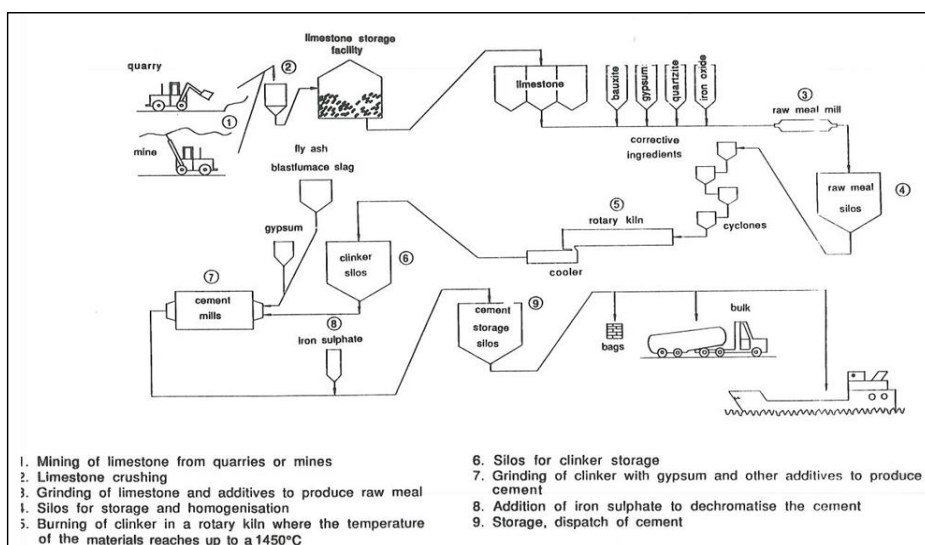
Produksjonsfasen for produktet

• Hovedprosessene ved Norcem Brevik er uttak av kalkstein fra to felt i nærheten av bedriften:

Dalen gruve og Bjørntvet dagbrudd, i tillegg til dagbrudd i Verdal.

• Kalksteinen tilsettes korreksjonsmaterialer, som kisavbrann, kvarts, oxiton, bauxitt og gips, og males og brennes ved høye temperaturer (1450°C) til klinker.

• Klinkeren finmales til sement. I maleprosessen tilsettes mindre mengder gips, jernsulfat og flyveaske i blandingssement.



### Datakvalitet:

Råvaregruppe	Datakvalitet	Kilde	Alder for data
Klinker	Spesifikke data	Norcems egne tall	2012
Flyveaske	Ikke relevant		-
Kalkmel	Spesifikke data	Norcems egne tall	2012
Gips	Databasedata	Ecolnvent	2006
Annet	Under Cut-off		

Spesifikke data er brukt for de materialer som utgjør vesentlige bidrag til miljøpåvirkning.

### Allokering:

For produksjonen hos Norcem er totalt forbruk for 2012 registrert og fordelt på produserte produkter på vektbasis .

I de tilfeller det benyttes et avfallsprodukt fra annen produksjon, allokeres forhold knyttet til framstilling til den opprinnelige produksjonen.

Alternativt brensel anses som avfallsprodukter fra annen produksjon. Påvirkninger knyttet til framstilling er allokeret til den opprinnelige produksjonen, mens påvirkninger ved forbrenning er allokeret til virksomheten som drar nytte av energien.

Alt utslipp og forbruk av ressurser knyttet til produksjonen av elektrisitet og framstilling av andre energibærere som er benyttet i produksjon ved råvarene i produktet er allokeret til råvarene og derved produktet i neste omgang.

### Cut-off kriterier:

Masser som utgjør mindre enn 1% er ikke tatt med.

## LCA: Scenarier og annen teknisk informasjon

Følgende informasjonen beskriver scenariene for modulene i EPDen.

**Tilleggsinformasjon:** Transport fra Produksjonssted til sentrallager i Norge  
Transporten skjer med Norcems egen bulkbåt for sement

50 km

### Annen teknisk informasjon

Ikke relevant

## LCA: Resultater

I modul A1 inngår produksjon av råvarer fra uttak av ressurser. A2 inkluderer transport av råvarer til Norcem, A3 inkluderer produksjonsprosessen hos Norcem.

Systemgrenser (X = inkludert, MID = modul ikke deklartert, MIR = modul ikke relevant)

Produktfase			Konstruksjon installasjon fase		Bruksfase								Slutfase				Etter endt levetid
Råmaterialer	Transport	Tilvirkning	Transport	Konstruksjon installasjon fase	Bruk	Vedlikehold	Reparasjon	Utskiftinger	Renovering	Operasjonell energibruk	Operasjonell vannbruk	Demontering	Transport	Avfallsbehandling	Avfall til deponi	Gjenbruk-gjenvinning-resirkulering-potensiale	
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	
X	X	X	MID	MID	MID	MID	MID	MID	MID	MID	MID	MID	MID	MID	MID	MID	

### Miljøpåvirkning

#### CEM I Anlegg

Parameter	A1	A2	A3	A1-A3
GWP	1,64	15,78	740,54	757,96
ODP	1,32E-07	1,91E-06	2,73E-06	4,76E-06
POCP	0,02	0,02	0,06	0,10
AP	0,10	0,14	1,07	1,31
EP	0,02	0,02	0,32	0,37
ADPM	3,01E-04	5,09E-06	1,66E-04	4,72E-04
ADPE	17,79	238,34	2899,07	3155,20

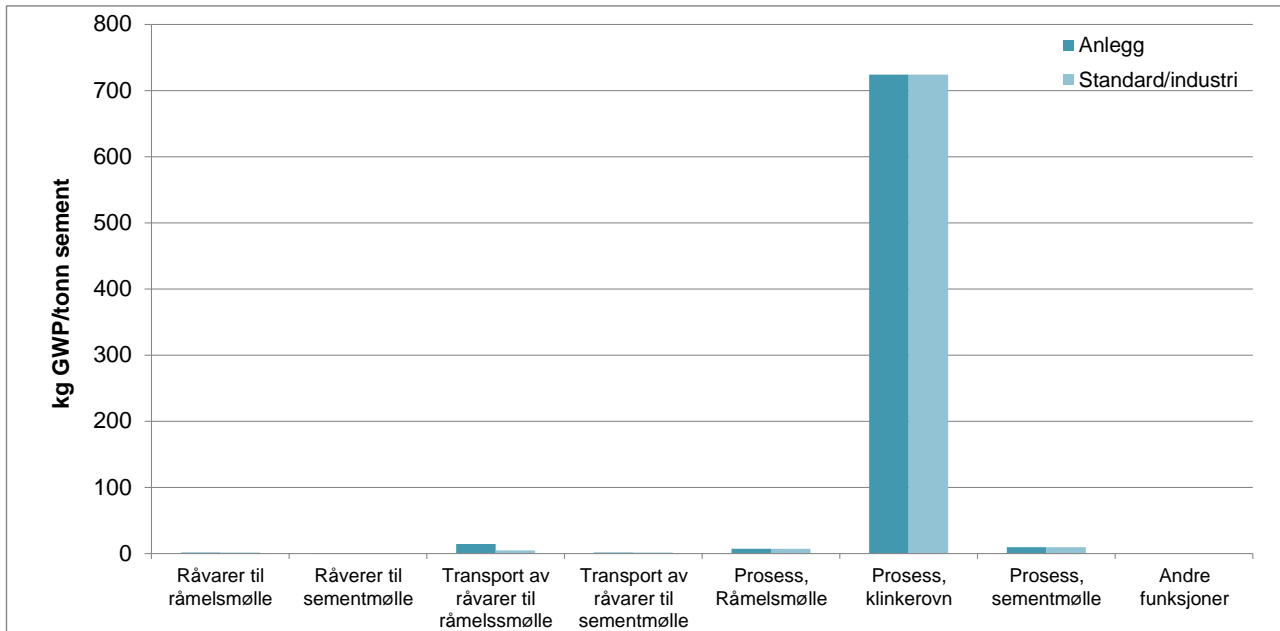
#### CEM I Industri og Standard

Parameter	A1	A2	A3	A1-A3
GWP	1,33	6,03	740,54	747,90
ODP	9,07E-08	6,92E-07	2,73E-06	3,51E-06
POCP	0,02	0,01	0,06	0,09
AP	0,10	0,06	1,07	1,23
EP	0,02	0,01	0,32	0,36
ADPM	3,93E-05	2,67E-06	1,66E-04	2,08E-04
ADPE	13,49	106,54	2899,07	3019,09

**GWP** Globalt oppvarmingspotensial (kg CO<sub>2</sub>-ekv.); **ODP** Potensial for nedbryting av stratosfærisk ozon (kg CFC11-ekv.); **POCP** Potensial for fotokjemisk oksidantdannning (kg C<sub>2</sub>H<sub>4</sub>-ekv.); **AP** Forsurningspotensial for kilder på land og vann (kg SO<sub>2</sub>-ekv.); **EP** Overgjødslingspotensial (kg PO<sub>4</sub><sup>-3</sup>-ekv.); **ADPM** Abiotisk uttømmingspotensial for ikke-fossile ressurser (kg Sb -ekv.); **ADPE** Abiotisk uttømmingspotensial for fossile ressurser (MJ)

Lese eksempel: 9,0 E -03 = 9,0 \* 10<sup>-3</sup>





### Ressursbruk

#### CEM I Anlegg

Parameter	A1	A2	A3	A1-A3
FPEE	7,45	1,02	791,28	799,75
FPEM	-	-	-	-
TFE	7,45	1,02	791,28	799,75
IFPE	19	239	2992	3250
IFPM	-	-	-	-
TIFE	26	240	3784	4050
SM	5,79	-	2,60E-11	5,79
FSB	-	-	-	-
IFSB	-	-	1567,54	1567,54
V	18,46	5,01	1240,73	1264,21

#### CEM I Industri og Standard

Parameter	A1	A2	A3	A1-A3
FPEE	10,29	0,51	791,28	802,08
FPEM	-	-	-	-
TFE	10,29	0,51	791,28	802,08
IFPE	15	107	2992	3114
IFPM	-	-	-	-
TIFE	25	107	3784	3916
SM	18,01	-	2,60E-11	18,01
FSB	-	-	-	-
IFSB	-	-	1567,54	1567,54
V	23,22	2,51	1240,73	1266,47

#

**FPEE** Fornybar primærenergi brukt som energibærere (MJ); **FPEM** Fornybar primærenergi brukt som råmateriale (MJ); **TFE** Total bruk av fornybar primærenergi (MJ); **IFPE** Ikke fornybar primærenergi brukt som energibærere (MJ); **IFPM** Ikke fornybar primærenergi brukt som råmateriale (MJ); **TIFE** Total bruk av ikke fornybar primærenergi (MJ); **SM** Bruk av sekundært materialer (kg); **FSB** Bruk av fornybart sekundært brensel (MJ); **IFSB** Bruk av ikke fornybart sekundært brensel (MJ); **V** Netto bruk av drikkevann (m<sup>3</sup>)

### Livsløpets slutt - Avfall

#### CEM I Anlegg

Parameter	A1	A2	A3	A1-A3
FA	2,33E-04	6,96E-05	9,11E-04	1,21E-03
IFA	1,72E-01	1,55E-01	7,56E+01	7,59E+01
RA				

#### CEM I Industri og Standard

Parameter	A1	A2	A3	A1-A3
FA	2,34E-04	2,84E-05	9,11E-04	1,17E-03
IFA	1,74E-01	7,90E-02	7,56E+01	7,58E+01
RA				

**FA** Avhendet farlig avfall (kg); **IFA** Avhendet ikke-farlig avfall (kg); **RA** Avhendet radioaktivt avfall (kg)

### Livsløpets slutt - Utgangsfaktorer

#### CEM I Anlegg

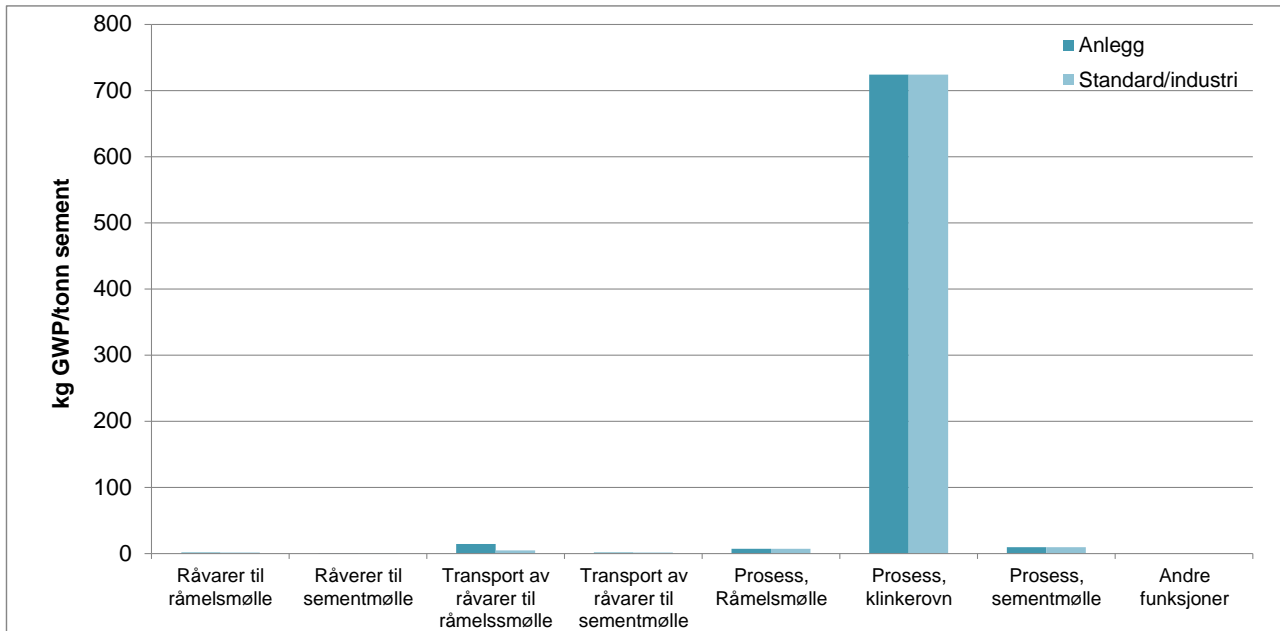
Parameter	A1	A2	A3	A1-A3
KG				
MR				
MEG				
EEE				
ETE				

#### CEM I Industri og Standard

Parameter	A1	A2	A3	A1-A3
KG				
MR				
MEG				
EEE				
ETE				

**KG** Komponenter for gjenbruk (kg); **MR** Materialer for resirkulering (kg); **MEG** Materialer for energigjenvinning (kg); **EEE** Eksportert elektrisk energi (MJ); **ETE** Eksportert termisk energi (MJ)

Lese eksempel:  $9,0 \text{ E}^{-03} = 9,0 * 10^{-3} = 0,009$



### Ressursbruk

#### CEM I Anlegg

Parameter	A1	A2	A3	A1-A3
FPEE	7,45	1,02	791,28	799,75
FPEM	-	-	-	-
TFE	7,45	1,02	791,28	799,75
IFPE	19	239	2992	3250
IFPM	-	-	-	-
TIFE	26	240	3784	4050
SM	5,79	-	2,60E-11	5,79
FSB	-	-	-	-
IFSB	-	-	1567,54	1567,54
V	18,46	5,01	1240,73	1264,21

#### CEM I Industri og Standard

Parameter	A1	A2	A3	A1-A3
FPEE	10,29	0,51	791,28	802,08
FPEM	-	-	-	-
TFE	10,29	0,51	791,28	802,08
IFPE	15	107	2992	3114
IFPM	-	-	-	-
TIFE	25	107	3784	3916
SM	18,01	-	2,60E-11	18,01
FSB	-	-	-	-
IFSB	-	-	1567,54	1567,54
V	23,22	2,51	1240,73	1266,47

#

**FPEE** Fornybar primærenergi brukt som energibærere (MJ); **FPEM** Fornybar primærenergi brukt som råmateriale (MJ); **TFE** Total bruk av fornybar primærenergi (MJ); **IFPE** Ikke fornybar primærenergi brukt som energibærere (MJ); **IFPM** Ikke fornybar primærenergi brukt som råmateriale (MJ); **TIFE** Total bruk av ikke fornybar primærenergi (MJ); **SM** Bruk av sekundært materialer (kg); **FSB** Bruk av fornybart sekundært brensel (MJ); **IFSB** Bruk av ikke fornybart sekundært brensel (MJ); **V** Netto bruk av drikkevann (m<sup>3</sup>)

### Livsløpets slutt - Avfall

#### CEM I Anlegg

Parameter	A1	A2	A3	A1-A3
FA	2,33E-04	6,96E-05	9,11E-04	1,21E-03
IFA	1,72E-01	1,55E-01	7,56E+01	7,59E+01
RA				

#### CEM I Industri og Standard

Parameter	A1	A2	A3	A1-A3
FA	2,34E-04	2,84E-05	9,11E-04	1,17E-03
IFA	1,74E-01	7,90E-02	7,56E+01	7,58E+01
RA				

**FA** Avhendet farlig avfall (kg); **IFA** Avhendet ikke-farlig avfall (kg); **RA** Avhendet radioaktivt avfall (kg)

### Livsløpets slutt - Utgangsfaktorer

#### CEM I Anlegg

Parameter	A1	A2	A3	A1-A3
KG				
MR				
MEG				
EEE				
ETE				

#### CEM I Industri og Standard

Parameter	A1	A2	A3	A1-A3
KG				
MR				
MEG				
EEE				
ETE				

**KG** Komponenter for gjenbruk (kg); **MR** Materialer for resirkulering (kg); **MEG** Materialer for energigjenvinning (kg); **EEE** Eksportert elektrisk energi (MJ); **ETE** Eksportert termisk energi (MJ)

Lese eksempel:  $9,0 \text{ E } -03 = 9,0 * 10^{-3} = 0,009$

## Spesifikke norske krav

### Elektrisitet

Nordisk produksjonsmiks

Klimagassutslipp 0,0458 kg CO<sub>2</sub> ekv/MJ

### Farlige stoffer

Produktet er ikke tilført stoffer fra REACH kandidatliste (pr.16.10.2013) over stoffer av svært stor bekymring, stoffer på den norske Prioritetslisten (pr.16.10.2013) og stoffer som fører til at produktet blir klassifisert som farlig avfall. Det kjemiske innholdet i produktet er i samsvar med den norske produktforskriften.

### Transport

Transport fra Produksjonssted til sentrallager i Norge er 50 km

### Inneklima

Materialet har ingen relevant påvirkning på inneklima

### Klimadeklarasjon

Foreligger ikke

## Bibliografi

NS-EN ISO 14025:2006	<i>Miljømerker og deklarasjoner - Miljødeklarasjoner type III - Prinsipper og prosedyrer.</i>
NS-EN ISO 14044:2006	Miljøstyring - Livsløpsvurderinger - Krav og retningslinjer
NS-EN 15804:2012	<i>Bærekraftig byggverk - Miljødeklarasjoner - Grunnleggende produktkategoriregler for byggevarer</i>
ISO 21930:2007	<i>Sustainability in building construction - Environmental declaration of building products</i>
Vold Mie: 2013	<i>Oppdaterte EPDer med 2012-tall for Norcem Brevik, Bakgrunnsrapport for verifisering. Mie Vold, Østfoldforskning, Fredrikstad, Mai 2013</i>
Institut Bauen und Umwelt e.V. (2012-1)	<i>Requirements on an Environmental Product Declaration (EPD) for Cement</i>
Institut Bauen und Umwelt e.V. (2012-2)	<i>Calculation Rules for the Life Cycle Assessment and Requirements on the Background Report</i>

 <b>epd-norge.no</b> The Norwegian EPD Foundation	<b>Utgiver</b> Næringslivets Stiftelse for Miljødeklarasjoner Postboks 5250 Majorstuen, 0303 Oslo Norge	Tlf: +47 23 08 80 00 e-post: <a href="mailto:post@epd-norge.no">post@epd-norge.no</a> web: <a href="http://www.epd-norge.no">www.epd-norge.no</a>
 <b>epd-norge.no</b> The Norwegian EPD Foundation	<b>Program operatør</b> Næringslivets Stiftelse for Miljødeklarasjoner Postboks 5250 Majorstuen, 0303 Oslo Norge	Tlf: +47 23 08 80 00 e-post: <a href="mailto:post@epd-norge.no">post@epd-norge.no</a> web: <a href="http://www.epd-norge.no">www.epd-norge.no</a>
 <b>HEIDELBERGCEMENT</b> Group	<b>Eier av deklarasjonen</b> Norcem AS Postboks 143 Lilleaker 0216 Oslo	Tlf: +47 22 87 84 00 Fax: +47 22 87 84 01 e-post: <a href="mailto:firmapost@norcem.no">firmapost@norcem.no</a> web: <a href="http://www.heidelbergcement.com/no">www.heidelbergcement.com/no</a>
 <b>Østfoldforskning</b>	<b>Forfatter av Livsløpsrapporten</b> Mie Vold Østfoldforskning as Gamle Beddingsvei 26, 1671 Kråkerøy	Tlf: +47 41 46 98 00 Fax: +47 69 34 24 94 e-post: <a href="mailto:mie@ostfoldforskning.no">mie@ostfoldforskning.no</a> web: <a href="http://www.ostfoldforskning.no">www.ostfoldforskning.no</a>

# Build-up Nepal - Carbon Evaluation of CSEB Blocks

Architect: --

Status: S3 - Suitable for Review and Comment

Title: Information Required Schedule

REF	ACTION	DATE CREATED	DATE DUE	DATE COMPLETE	EVIDENCE	MF LLP NOTES	BUILD UP NEPAL NOTES
01	Please provide the amount of cement used per block and provide additional information regarding the transportation and manufacturing of the cement. (units - kg or m <sup>3</sup> )	03/11/2020	27/11/2020		Specifications Photograph of the vehicle Vehicle datasheet	•Where is the cement sourced from? •How is it delivered to site? •Vehicle capacity and trips (example: 1 ton per vehicle, 5 vehicles per housing type)	
02	Please provide the amount of sand used per block and provide additional information regarding the transportation and where and how the sand is extracted and transported. (units - kg or m <sup>3</sup> )	03/11/2020	27/11/2020		Specifications Photograph of the vehicle Photograph of vehicle capacity	•Where is the sand sourced from? •How is it delivered to site? •Type of vehicle/ fuel used? •Vehicle capacity and trips (example: 1 ton per vehicle, 5 vehicles per housing type)	
03	Provide information regarding the testing of the soil (units - kg or m <sup>3</sup> of soil being extracted for testing) and provide additional information as per Notes	03/11/2020	27/11/2020		Report	Shipping samples – transport type/ fuel type, distance, frequency of samples, results	
04	Please could we request all the information we can have for the construction workers. This includes: •Number of workers (total of people working for the whole construction process) •Number of people travelling to get to site every day, people per vehicle •Number of people walking to site/ staying overnight •People bringing food from home vs people eating on site	03/11/2020	27/11/2020		Summary report and name of the designated person interviewing and collating the data		
05	Please provide the number of construction workers per day and the duration of the construction.	03/11/2020	27/11/2020		Short summary report for the required amount of workers on site		
06	Please provide: •Amount of construction waste generated and transported out of the site (kg or m <sup>3</sup> ) •Amount of cooking or other types of waste from the workers (kg or m <sup>3</sup> ) (how is it disposed? Is it transported out of the site? - depending on the type of disposal, we need information on the vehicle and distances) •Amount of wastewater at the premises	03/11/2020	27/11/2020		Waste disposal commissioning Waste monitoring summary Name of designated person collating the evidence	The biochemical oxygen demand (BOD) of the discharged wastewater from toilets can be assumed based on amount of workers on site per day, and amount of meals. BOD is relevant as the process releases methane.	
07	Materials used for the vehicles themselves and the CSEB compressor machine	03/11/2020	27/11/2020		Photograph of the vehicle CSEB compressor machine specifications	Vehicles' manufacturer, model and year CSEB compressor machine - is it locally manufactured? Is it possible to get information about how is it made?	
08	We need as much information on the transportation as possible. Some of the main CO2 emissions are associated with: •Fuel used for transportation of people (public transport and private transport) •Fuel used for transportation of construction materials •Fuel used for transportation of construction equipment •Fuel used for transportation of food on site •Fuel used for transportation of waste	03/11/2020	27/11/2020		Short summary report showing monitoring of vehicle and fuel use Name of designated person for collating the evidence		
09	Food consumption - Is food cooked on site? Is it wood stove/ gas/ electric? (units - amounts of meals per person per day, type of meals - main ingredients)	03/11/2020	27/11/2020		Photographic evidence of the cooking equipment Short summary report on daily meals consumption Name of designated person		
10	Electricity consumption - Charging stations, equipment, lighting etc. (kWh capacity of equipment, average hours of usage)	03/11/2020	27/11/2020		Energy bill Specifications on equipment and lighting on site		

## CSEB CO2 Base Data (Build up Nepal Engineering)

### 02.02.21

#### Brick data:

Size: 300x150x100 mm

Circular holes: 45 mm diameter

Central rectangular hole: 25x50 mm

Side rectangular hole: 25x25 mm

Average weight: 7.2 kg



#### Mix in the bricks (CSEB):

Cement 10% (0.72 kg per brick)

Sand average 35% (2,52 kg per brick)\*

Soil 55% (3,96 kg per brick)\*

Note! The mix of sand and soil is different from location to location and depends on how much sand is already there in the soil. 35% is a weighted average but it ranges from 10-50%

## TRANSPORTATION, CEMENT AND SAND

Note, we have 300 different sites, some just 2 km from the cement factory while others are far up in the mountains. Here we will provide the data of 2 of our sites in different scenarios.

Question	Entrepreneur Name	Deepak Hamal	Toyaraj Thekare
	Location	Makwanpur, Palung	Darchula, Nepal
Mix ratio	Cement %	10	15
	Sand %	60	50
	Soil %	30	35
Where is cement sourced from?	Location	Hetauda, Nepal	Parsa, Nepal
Transport cement factory to depo	Capacity of vehicle	21 ton , 420 bags of cement	22 ton , 420 bags of cement
	Brand & model	Tata Lpk 2518	Tata Lpk 2518
	Website link of vehicle	<a href="https://tatatrucks.tatamotors.com/tata-trucks/tippers/tata-lpk-2518/overview.aspx">https://tatatrucks.tatamotors.com/tata-trucks/tippers/tata-lpk-2518/overview.aspx</a>	<a href="https://tatatrucks.tatamotors.com/tata-trucks/tippers/tata-lpk-2518/overview.aspx">https://tatatrucks.tatamotors.com/tata-trucks/tippers/tata-lpk-2518/overview.aspx</a>
	Fuel Type	Diesel	Diesel
	Distance	73 Kms	976 Kms
Transport cement depo to production site	Capacity of vehicle	4 ton, 80 bags	4 ton, 80 bags; Mule(animal) carrying 4 bags per mule(animal)
	Brand & model	Tata 407	Tata 408;Mule (animal)
	Website link of vehicle	<a href="https://www.tatamotors.com.np/product/light-trucks/rigid/4-tonner-cargo-truck/">https://www.tatamotors.com.np/product/light-trucks/rigid/4-tonner-cargo-truck/</a>	<a href="https://www.tatamotors.com.np/product/light-trucks/rigid/4-tonner-cargo-truck/">https://www.tatamotors.com.np/product/light-trucks/rigid/4-tonner-cargo-truck/</a>

	Fuel Type	Diesel	Diesel; Food for animal
	Distance	13 Kms	48 Kms vehicle + 21 Kms Mule (animal)
<b>Where is sand sourced from?</b>	Location	Naubise, Dhading, Nepal	21 Kms Mule (animal)
<b>How is it delivered to site?</b>	Capacity of vehicle	8m3 sand	0.8 cum per Mule (animal)
	Brand & model	Eicher 1080	Mule (animal)
	Website link of vehicle	<a href="https://indotrux.com/new-trucks/EICHERPRO-1080/470">https://indotrux.com/new-trucks/EICHERPRO-1080/470</a>	<a href="https://en.wikipedia.org/wiki/Mule">https://en.wikipedia.org/wiki/Mule</a>
	Fuel Type	Diesel	Food for animal
	Distance	32 Kms	21 Kms Mule (animal) walking
<b>Transport of CSEB from factory to site</b>	Capacity of vehicle	500 bricks	40 bricks per Mule (animal)
	Brand & model	Mahindra Tractor	Mule (animal)
	Website link of vehicle	<a href="https://www.mahindra.com.np/products/novo-605-2wd-4wd/">https://www.mahindra.com.np/products/novo-605-2wd-4wd/</a>	<a href="https://en.wikipedia.org/wiki/Mule">https://en.wikipedia.org/wiki/Mule</a>
	Fuel Type	Diesel	Food for animal
	Distance	2 Kms	3 Kms
<b>Nr of workers in production</b>		6	4
<b>Nr or bricks made per day</b>		800	500
<b>Brick makers Transport to site</b>		Walking	Walking
<b>Brick making machine (type and no)</b>		2 DM Manual (no electricity)	1 DM Manual (no electricity)
<b>Food</b>		make their own food in the labor camp in the factory	Bring Food from home
<b>Wastage materials</b>		Empty Cement bags, Damaged and Broken Bricks	Empty Cement bags, Damaged and Broken Bricks



### Material requirement for 1m<sup>2</sup> of wall of 1:4 ratio:

	Fired brick	CSEB
Nr of bricks	128.80	33.15
Cement for mortar (bags)	0.32	0.13
Sand for mortar (cubic meters)	0.07	0.03
Water (Liters)	23	6.3
Manpower labor (man-days)	0.345	0.11
Manpower Mason( man-days)	0.506	0.18

\*Based on Nepal Building Code and Civil Works norms DUDBC (approved for Fired bricks and on the process of approval for CSEB)

### CSEB machine

The machine is manufactured in India and delivered to Nepal in Tata Lpk 2518 (<https://tatatrucks.tatamotors.com/tata-trucks/tippers/tata-lpk-2518/overview.aspx>) with 16 machines in one shipment.

the machine is manual and don't use any electricity or fuel to operate.

The machine is transported from Build up Nepal office in Kathmandu to the entrepreneur's location by local transport company. They use different types of vehicle, but it is a shared transport.

One machine is used for several years making 100,000 – 500,000 bricks.

## Build up Nepal - data on traditional brick sourcing

Question	Entrepreneur Name	Deepak Hamal	Toyaraj Thekare
	Location	Makwanpur, Palung	Darchula, Nepal
Transport Coal for burning Red Bricks in factory from India	Kiln for Red Bricks	Naubise,Dhading,Nepal	Dadeldhura
	Capacity of vechile	21 ton	21 ton
	Brand & model	Tata Lpk 2518	Tata Lpk 2518
	Website link of vechile	<a href="https://tatatrucks.tatamotors.com/tata-trucks/tippers/tata-lpk-2518/overview.aspx">https://tatatrucks.tatamotors.com/tata-trucks/tippers/tata-lpk-2518/overview.aspx</a>	<a href="https://tatatrucks.tatamotors.com/tata-trucks/tippers/tata-lpk-2518/overview.aspx">https://tatatrucks.tatamotors.com/tata-trucks/tippers/tata-lpk-2518/overview.aspx</a>
	Fuel Type Distance	Diesel 635 kms	Diesel 785 Kms
	% of fuel per 1brick	0.1%	0.1%
	total km per trip (km)	635	785
	fuel consumption per km (l/km)	0.35	0.35
	co2 emissions per litre (kg CO2 /l)	2.68	2.68
	Total emissions per trip (kg CO2 )	596	736.33
	Total emision per brick (kgCO2e)	0.30	0.74
	Total emissions per kg of brick kgCO2e/kg	0.13	0.32
	total emissions per m2 (kgCO2e/m2kgCO2e/m2)	38.4	95.0
Transport Red Bricks to site	Capacity of vechile	2000 bricks per trip	2000 bricks per trip; Mule(animal) carrying 100 bricks per mule(animal)
	Brand & model	Tata 407	Tata 407;Mule (animal)
	Website link of vechile	<a href="https://www.tatamotors.com.np/product/light-trucks/rigid/4-tonner-cargo-truck/">https://www.tatamotors.com.np/product/light-trucks/rigid/4-tonner-cargo-truck/</a>	<a href="https://www.tatamotors.com.np/product/light-trucks/rigid/4-tonner-cargo-truck/">https://www.tatamotors.com.np/product/light-trucks/rigid/4-tonner-cargo-truck/</a>
	Fuel Type	Diesel	Diesel; Food for animal
	Distance	32 Kms	48 Kms vechile + 21 Kms Mule (animal)
Vehicle	% of fuel per 1brick	0.1%	0.1%
	total km per trip (km)	32	785
	fuel consumption per km (l/km)	0.35	0.35
	co2 emissions per litre (kg CO2 /l)	2.68	2.68
	Total emissions per trip (kg CO2 )	30	48
	Total emision per brick (kgCO2e)	0.02	0.05
	Total emissions per kg of brick kgCO2e/kg	0.01	0.02
	total emissions per m2 (kgCO2e/m2kgCO2e/m2)	1.9	6.2

## Statement of Verification

BREG EN EPD No.: 000002

ECO EPD Ref. No. 000092

This is to verify that the

### Environmental Product Declaration

provided by:

The Brick Development Association

is in accordance with the requirements of:

EN 15804:2012+A1:2013

and

BRE Global Scheme Document SD207

This declaration is for:

BDA Generic Brick

Issue 4



### Company Address

The Building Centre  
26 Store Street  
London  
WC1E 7BT



Signed for BRE Global Ltd

Laura Critien  
Operator

19 February 2019  
Date of this Issue

12 December 2013  
Date of First Issue

18 February 2024  
Expiry Date



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## Environmental Product Declaration

EPD Number: 000002

### General Information

EPD Programme Operator	Applicable Product Category Rules
BRE Global Watford, Herts WD25 9XX United Kingdom	BRE Environmental Profiles 2013 Product Category Rules for Type III environmental product declaration of construction products to EN 15804:2012+A1:2013
Commissioner of LCA study	LCA consultant/Tool
Brick Development Association (BDA) Ltd 26 Store Street Fitzrovia London WC1E 7BT United Kingdom	Fei Zhang BRE Bucknalls Lane Watford WD25 9XX
Declared/Functional Unit	Applicability/Coverage
1 tonne of brick	Sector UK Average
EPD Type	Background database
Cradle to Gate with all options plus module D	ecoinvent
Demonstration of Verification	
CEN standard EN 15804 serves as the core PCR <sup>a</sup>	
Independent verification of the declaration and data according to EN ISO 14025:2010 <input type="checkbox"/> Internal <input checked="" type="checkbox"/> External	
(Where appropriate <sup>b</sup> ) Third party verifier: Nigel Jones	
a: Product category rules 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+A1:2013. 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+A1:2013 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
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Note: Ticks indicate the Information Modules declared.

## Manufacturing sites

Manufacturing data was provided by members of the BDA covering 46 UK manufacturing sites and representing 99% of UK brick production. Manufacturers and site addresses are included in the LCA report.

## Construction Product:

### Product Description

Bricks have a wide range of applications across the construction industry. Most bricks are used in cavity walls in building projects. Bricks generally form the outside face of the wall. Protected by the outer brick there is an insulation filled cavity (either full-filled or part-filled), an internal skin of thermal blockwork, a timber or steel framed structure, finished with either dry lined or a wet plastered finish which completes a typical wall. Bricks are also used fair faced internally replacing the internal blockwork and plasterwork, and for both free standing walls and civil engineering structures.

The members of the BDA manufacture a wide variety of bricks, which can vary in composition, colour, texture, size and production process. There are four main manufacturing processes by which bricks are produced in the UK; extrusion, soft mud moulding, handmade moulding and semi-dry pressing. In the UK, 'extrusion' and 'soft mud' are dominant. This LCA is for a generic UK brick which covers all brick types and production process and is based on data representative of 99% brick production by BDA member companies (with complete data returns from eight companies across 46 manufacturing sites).

### Technical Information

Bricks are made to a range of specifications, so characteristics can vary. The basic characteristics of the BDA average UK brick can be seen in the table below. The weight of a standard brick was given as supplied by the BDA to allow conversion of the results per declared unit to a per average brick basis. As other characteristics such as fire resistance and compressive strength vary between types of brick, this information can be found on the datasheets of specific bricks.

Property	Value, Unit
Dimensions	215 mm x 102.5 mm x 65 mm
Dry brick weight	2.13 kg

All UK manufactured bricks are produced according to the requirements of BS EN 771-1: Specification for masonry units: Clay masonry units

## Main Product Contents

According to BDA, the average UK brick contains no substances that are listed in the ‘Candidate List of Substances of very high concern for authorisation’. The composition of the average product modelled in this project is obtained from the total raw material usages supplied by all participating members.

Composition of the BDA average brick based on input masses of used raw materials can be seen in the table below.

Material/Chemical Input	%
Clays and shales	92
Sand	6
Inorganic additive	2

## Manufacturing Process

Most brickworks have their own onsite quarry or are in close proximity to one. However, depending on the type of clay required, clay can also be sourced from quarries further afield. Once extracted from the quarry, the raw clay undergoes a series of processes, which generally includes crushing and mixing with water, in order to transform it into a malleable material.

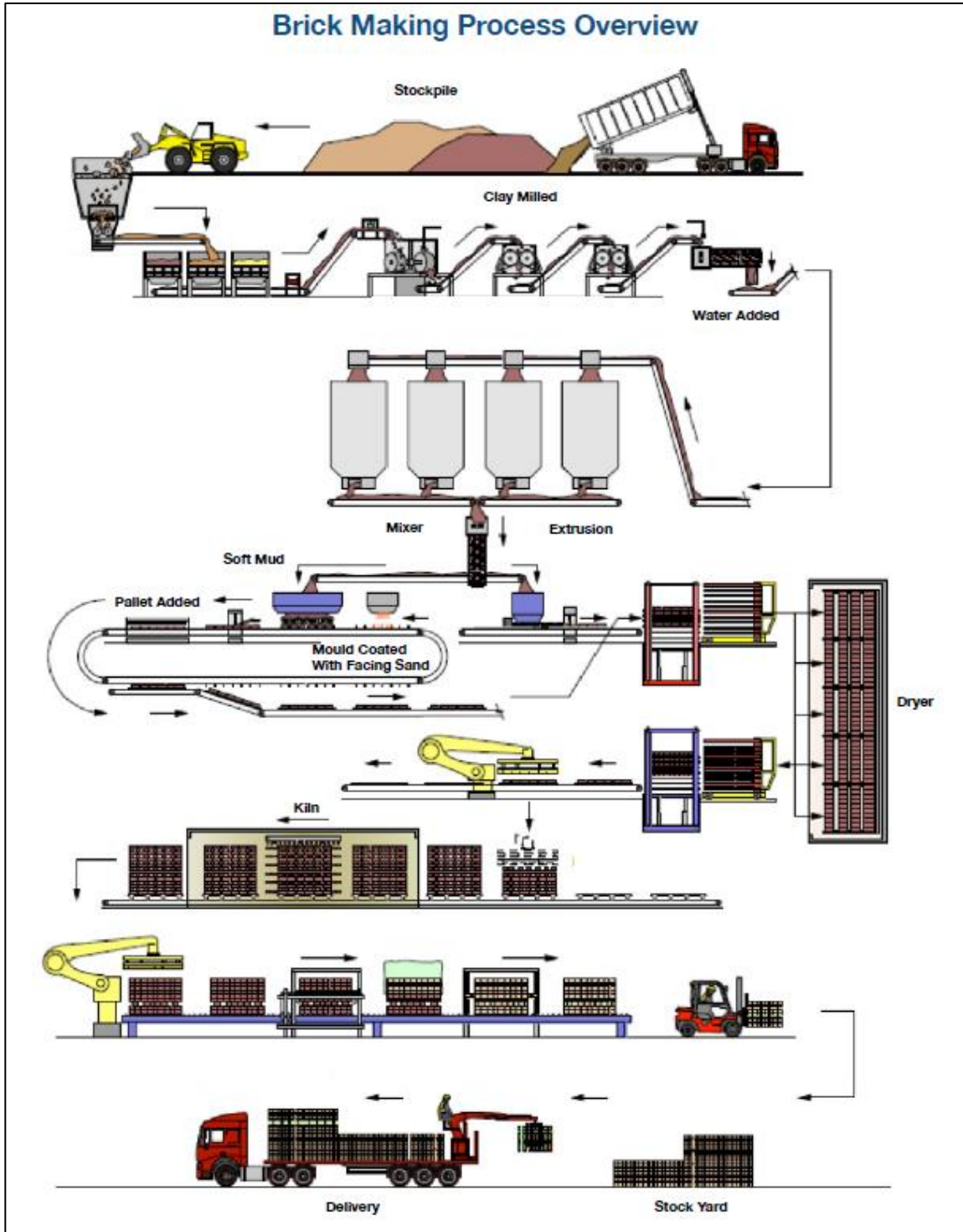
As mentioned previously there are four main manufacturing processes by which bricks are produced in the UK, although extrusion and soft mud moulding are the most dominant. The majority of UK clay types can be used, although the harder less clay rich shales and marls lend themselves more to extrusion with the more clay rich clays used in the soft mud process.

The extrusion process typically produces bricks with perforations within the body of the brick, ranging from highly perforated units through to the more traditional 3 and 10 holes. The perforations aid in the formation process of the bricks allowing the clay to be compressed in the extrusion die, however the main benefits come from the drying and firing process, where the additional voids within the bricks, not only reduce the amount of raw material in the brick, but also increases the surface area thus allowing for more efficient drying and firing.

The extrusion process is also often described as wire cut, as the column of clay is pushed out of the extrusion head the bricks are formed by a wire cutter normally cutting a number of bricks in the column. These bricks are then dried prior to entering the kiln for vitrifying which normally takes place at around 1000°C. Soft mud bricks are typically ‘solid’ or ‘frogged’ in appearance. The ‘frog’ is the name given to the indentation typically on the upper bedface of the brick, and again reduces the amount of raw material in the brick, and increases the surface area, thus again aiding drying and firing. The frog also aids the structural performance when laid with mortar. Soft mud bricks or ‘stock’ bricks have higher water absorbency prior to being dried. The characteristic sanded face is part of the requirement to allow the green brick to be released from the mould. After firing and cooling, bricks are sorted, packaged, and then stored in the stockyard or distributed.

## Process flow diagram

Typical process flow for the manufacture of moulded clay bricks, provided by the BDA can be seen below.



### Construction Installation

Bricks are generally hand by laid, on-site, with a cementitious or lime based mortar to bond the individual units together.



## Use Information

The service life of the BDA average UK brick is given as minimum of 150 years for a half brick thick cavity wall. For a full brick construction the minimum life expectancy is 600 years. These figures are derived from a 2007 research thesis by the Engineering and Physical Sciences Research Council. No maintenance of brickwork is expected for a minimum of 60 years. The most common maintenance required at this stage is the repointing of mortar.

## End of Life

At the end of life there are a number of common scenarios for brickwork. Firstly brickwork can be dismantled, with the individual units being separated, clean and reused. Secondly the brickwork can be demolished, broken down to a smaller aggregate size and used for a variety of purposes, such as foundation construction.

## Life Cycle Assessment Calculation Rules

### Declared / Functional unit description

The declared unit is 1 tonne of BDA average UK brick over a 60 year study period.

### System boundary

In accordance with the modular approach as defined in EN 15804:2012, this cradle-to-gate with all options plus module D EPD, includes the processes covered in the manufacturing, construction, use and end-of-life stages, as well as considering a benefits and loads beyond the system boundary scenario. The modules covered are A1-A3, A4, A5, B1 – B7, C1 – C4 and D.

### Data sources, quality and allocation

Specific primary data derived from total site data provided by BDA members, covering 46 manufacturing sites in the UK, has been modelled. In accordance with the requirements of EN 15804, the most current available data at the time of collection, has been used, covering the period of 1<sup>st</sup> January 2017 to 31<sup>st</sup> December 2017. Secondary data has been used for upstream and downstream processes that are beyond the control of the manufacturer such as raw material production. SimaPro v8 software was used to carry out the LCA modelling with background LCI datasets taken from the ecoinvent v3.2 database.

As total values used to create the stated production output were supplied, no allocation was required. For transport of fuels and of packaging materials to site, a nominal value of 50 km by road was assumed.

### Cut-off criteria

Full data collected by the BDA as supplied by BDA members for 46 UK manufacturing sites was used. The inventory process in this LCA includes all data related to raw material, packaging material, and their associated transport to the manufacturing site. Process energy and water use, direct production waste, non-production waste, wastewater to sewer, and emissions to air generated by the firing of the green bricks, are included.

## LCA Results

The results for the declared unit of 1 tonne of BDA average UK brick can be found below. As the average brick is assumed by the BDA to have a mass of 2.13 kg, results can be calculated per average brick by dividing individual values in results tables by a factor of (1000 / 2.13).

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

			Parameters describing environmental impacts						
			GWP kg CO <sub>2</sub> equiv.	ODP kg CFC 11 equiv.	AP kg SO <sub>2</sub> equiv.	EP kg (PO <sub>4</sub> ) <sup>3-</sup> equiv.	POCP kg C <sub>2</sub> H <sub>4</sub> equiv.	ADPE kg Sb equiv.	ADPF MJ, net calorific value.
Product stage	Raw material supply	A1	AGG	AGG	AGG	AGG	AGG	AGG	AGG
	Transport	A2	AGG	AGG	AGG	AGG	AGG	AGG	AGG
	Manufacturing	A3	AGG	AGG	AGG	AGG	AGG	AGG	AGG
	Total (of product stage)	A1-3	213	1.85e-5	3.49	0.107	0.177	1.24e-4	2370
Construction process stage	Transport	A4	16.7	3.08e-6	0.0559	0.0148	0.00975	4.40e-5	253
	Construction	A5	63.7	3.64e-6	0.313	0.0479	0.0249	4.47e-5	429
Use stage	Use	B1	MNR	MNR	MNR	MNR	MNR	MNR	MNR
	Maintenance	B2	MNR	MNR	MNR	MNR	MNR	MNR	MNR
	Repair	B3	MNR	MNR	MNR	MNR	MNR	MNR	MNR
	Replacement	B4	MNR	MNR	MNR	MNR	MNR	MNR	MNR
	Refurbishment	B5	MNR	MNR	MNR	MNR	MNR	MNR	MNR
	Operational energy use	B6	MNR	MNR	MNR	MNR	MNR	MNR	MNR
	Operational water use	B7	MNR	MNR	MNR	MNR	MNR	MNR	MNR
End of life	Deconstruction, demolition	C1	MNR	MNR	MNR	MNR	MNR	MNR	MNR
	Transport	C2	0.251	4.62e-8	8.39e-4	2.21e-4	1.46e-4	6.61e-7	3.79
	Waste processing	C3	3.20	5.88e-7	0.0245	0.00610	0.00421	1.10e-6	46.2
	Disposal	C4	1.03	2.73e-7	0.00724	0.00239	0.00120	1.47e-6	25.4
Potential benefits and loads beyond the system boundaries	Reuse, recovery, recycling potential	D	-16.0	-1.83e-6	-0.0978	-0.0283	-0.0121	-7.70e-5	-229

GWP = Global Warming Potential;  
 ODP = Ozone Depletion Potential;  
 AP = Acidification Potential for Soil and Water;  
 EP = Eutrophication Potential;

POCP = Formation potential of tropospheric Ozone;  
 ADPE = Abiotic Depletion Potential – Elements;  
 ADPF = Abiotic Depletion Potential – Fossil Fuels;

## LCA Results (continued)

Parameters describing resource use, primary energy			PERE	PERM	PERT	PENRE	PENRM	PENRT
			MJ	MJ	MJ	MJ	MJ	MJ
Product stage	Raw material supply	A1	AGG	AGG	AGG	AGG	AGG	AGG
	Transport	A2	AGG	AGG	AGG	AGG	AGG	AGG
	Manufacturing	A3	AGG	AGG	AGG	AGG	AGG	AGG
	Total (of product stage)	A1-3	120	1.85e-4	120	2430	0	2430
Construction process stage	Transport	A4	3.35	1.25e-5	3.35	251	0	251
	Construction	A5	71.6	6.22e-5	71.6	542	0	542
Use stage	Use	B1	MNR	MNR	MNR	MNR	MNR	MNR
	Maintenance	B2	MNR	MNR	MNR	MNR	MNR	MNR
	Repair	B3	MNR	MNR	MNR	MNR	MNR	MNR
	Replacement	B4	MNR	MNR	MNR	MNR	MNR	MNR
	Refurbishment	B5	MNR	MNR	MNR	MNR	MNR	MNR
	Operational energy use	B6	MNR	MNR	MNR	MNR	MNR	MNR
	Operational water use	B7	MNR	MNR	MNR	MNR	MNR	MNR
End of life	Deconstruction, demolition	C1	MNR	MNR	MNR	MNR	MNR	MNR
	Transport	C2	0.0503	1.87e-7	0.0503	3.76	0	3.76
	Waste processing	C3	0.274	6.37e-7	0.274	45.5	0	45.5
	Disposal	C4	0.776	2.12e-6	0.776	25.6	0	25.6
Potential benefits and loads beyond the system boundaries	Reuse, recovery, recycling potential	D	-12.6	-3.68e-5	-12.6	-241	0	-241

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)

Parameters describing resource use, secondary materials and fuels, use of water						
			SM	RSF	NRSF	FW
			kg	MJ net calorific value	MJ net calorific value	m <sup>3</sup>
Product stage	Raw material supply	A1	AGG	AGG	AGG	AGG
	Transport	A2	AGG	AGG	AGG	AGG
	Manufacturing	A3	AGG	AGG	AGG	AGG
	Total (of product stage)	A1-3	0	0	0	0.861
Construction process stage	Transport	A4	0	0	0	0.0547
	Construction	A5	0	0	0	0.571
Use stage	Use	B1	MNR	MNR	MNR	MNR
	Maintenance	B2	MNR	MNR	MNR	MNR
	Repair	B3	MNR	MNR	MNR	MNR
	Replacement	B4	MNR	MNR	MNR	MNR
	Refurbishment	B5	MNR	MNR	MNR	MNR
	Operational energy use	B6	MNR	MNR	MNR	MNR
	Operational water use	B7	MNR	MNR	MNR	MNR
End of life	Deconstruction, demolition	C1	MNR	MNR	MNR	MNR
	Transport	C2	0	0	0	8.21e-4
	Waste processing	C3	0	0	0	0.00797
	Disposal	C4	0	0	0	0.0286
Potential benefits and loads beyond the system boundaries	Reuse, recovery, recycling potential	D	0	0	0	-0.373

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)

Other environmental information describing waste categories			HWD	NHWD	RWD
			kg	kg	kg
Product stage	Raw material supply	A1	AGG	AGG	AGG
	Transport	A2	AGG	AGG	AGG
	Manufacturing	A3	AGG	AGG	AGG
	Total (of product stage)	A1-3	1.39	5.41	0.00697
Construction process stage	Transport	A4	0.106	11.8	0.00174
	Construction	A5	25.5	5.45	0.00295
Use stage	Use	B1	MNR	MNR	MNR
	Maintenance	B2	MNR	MNR	MNR
	Repair	B3	MNR	MNR	MNR
	Replacement	B4	MNR	MNR	MNR
	Refurbishment	B5	MNR	MNR	MNR
	Operational energy use	B6	MNR	MNR	MNR
	Operational water use	B7	MNR	MNR	MNR
End of life	Deconstruction, demolition	C1	MNR	MNR	MNR
	Transport	C2	0.00159	0.177	2.61e-5
	Waste processing	C3	0.0292	0.0235	3.32e-4
	Disposal	C4	0.0191	100	1.57e-4
Potential benefits and loads beyond the system boundaries	Reuse, recovery, recycling potential	D	-0.218	-5.36	-0.00114

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

## LCA Results (continued)

Other environmental information describing output flows – at end of life						
			CRU	MFR	MER	EE
			kg	kg	kg	MJ per energy carrier
Product stage	Raw material supply	A1	AGG	AGG	AGG	AGG
	Transport	A2	AGG	AGG	AGG	AGG
	Manufacturing	A3	AGG	AGG	AGG	AGG
	Total (of product stage)	A1-3	33.6	0	0	0
Construction process stage	Transport	A4	0	0	0	0
	Construction	A5	51.7	0	0	0
Use stage	Use	B1	MNR	MNR	MNR	MNR
	Maintenance	B2	MNR	MNR	MNR	MNR
	Repair	B3	MNR	MNR	MNR	MNR
	Replacement	B4	MNR	MNR	MNR	MNR
	Refurbishment	B5	MNR	MNR	MNR	MNR
	Operational energy use	B6	MNR	MNR	MNR	MNR
	Operational water use	B7	MNR	MNR	MNR	MNR
End of life	Deconstruction, demolition	C1	MNR	MNR	MNR	MNR
	Transport	C2	0	0	0	0
	Waste processing	C3	0	0	0	0
	Disposal	C4	900	0	0	0
Potential benefits and loads beyond the system boundaries	Reuse, recovery, recycling potential	D	0	0	0	0

CRU = Components for reuse;  
MFR = Materials for recycling

MER = Materials for energy recovery;  
EE = Exported Energy

## Scenarios and additional technical information

The beyond-the-gate scenarios modelled and relevant quantities, are described in the table below. Note that unless otherwise stated, values are per declared unit (i.e. per tonne) of BDA average UK brick.

Scenarios and additional technical information			
Scenario	Parameter	Units	Results
A4 – Transport to the building site	As brick delivery could be to almost anywhere, an distance of 100 km was assumed to allow simple extrapolation of results to further distances, if necessary. Fuel consumption and capacity utilisation are as specified in the ecoinvent v3.2 dataset used (Transport, freight, lorry 16-32 metric ton, EURO5 {GLO}  market for   Alloc Def, U)		
	Lorry - diesel	Fuel consumption (g/tkm)	2.5
	Distance	km	100
	Capacity utilisation (incl. empty returns)	%	24
	Bulk density of transported products	kg/m <sup>3</sup>	1485
A5 – Installation in the building	It is assumed that for whatever purpose the brick will have within a building or construction, mortar will be required to install the brick. The mortar quantity required as well as its composition, has been based on that used in the GreenGuide for brick and mortar external walls (element 806470537). Wastage percentages are also based that element. Uplifts of the equivalent percentage have been applied to A1-A3 and A4, and added to module A5, accordingly. It is assumed that the mortar will come from a supplier local to the installation site and a value of 25 km has been assumed for the supply distance.		
	Ancillary material: mortar (cement to sand 1:4, w/c 0.5)	kg	252
	Transport of mortar to construction site	km	25
	Installation wastage to reuse: brick Installation wastage to landfill: mortar (cement to sand 1:4, w/c 0.5)	% %	5 10
B1 – Use	Bricks do not emit any emissions to air during their use, so this module is not relevant (MNR).		
B2 – Maintenance	Bricks once installed require no maintenance themselves, so this module is not relevant (MNR).		
B3 – Repair	It is assumed that the brick should not need any repair during its service life or the study period, so this module is not relevant (MNR).		
B4 – Replacement	The service life of the brick is at least as long as the 60-year study period and likely life of the building so no replacements are expected. Therefore, this module is not relevant (MNR).		
B5 – Refurbishment	It has been assumed that no refurbishment action that relates to the brick will be required during the 60-year study period, so this module is not relevant (MNR)		
Reference service life	The BDA gives a service life of 150 years for the brick		
B6 – Use of energy	No energy is required for the brick to 'operate' during its use. Therefore, this module is not relevant (MNR).		
B7 – Use of water	No water is required for the brick to 'operate' during its use. Therefore, this module is not relevant (MNR).		
C1 – End-of-life deconstruction	It is assumed that as when the brick is removed from its structure, this is part of demolition of the whole structure. Therefore, impacts must be allocated to the whole structure and it is assumed that those allocated to the brick alone are negligible, and can be assumed to be zero.		

Scenarios and additional technical information			
Scenario	Parameter	Units	Results
C2 – End-of-life transport	As will be described in module C3 and C4, 10% of the declared unit is assumed to go to landfill whilst the remaining 90% exits the system boundary to be reused on site. It is assumed that the landfill site is local and 15 km away from the construction site. As per module A4, fuel consumption and capacity utilisation are as specified in the ecoinvent v3.2 dataset used (Transport, freight, lorry 16-32 metric ton, EURO5 {GLO}  market for   Alloc Def, U)		
	Lorry - diesel	Fuel consumption (g/tkm)	2.5
	Distance	km	15
	Capacity utilisation (incl. empty returns)	%	24
	Bulk density of transported products	kg/m <sup>3</sup>	1485
C3 End-of-life pre-processing	As described in module C4 (below), it is assumed that 100% of the brick rubble is crushed. The diesel consumption value was provided and derived by the BDA based on data from members' crushing operations.		
	Diesel consumption for crushing	litres	0.88
C4 End-of-life disposal	This scenario is based on a 90% reuse / 10% landfill split of construction waste, as evidenced in the UK Government statistics on waste (see references). The scenario supplied by the BDA and modelled in this project, assumes that once the wall containing the brick has been knocked down, 100% of it is crushed onsite. Only 90% of the resulting crushed brick is then usable to go on and leave the system boundary as recycled aggregate onsite, and the remaining 10% is not suitable for reuse, meaning that it goes to landfill		
	Crushed brick leaving system as recycled aggregate: Crushed brick going to landfill:	kg kg	900 100
Module D	After demolition clay brick is crushed on site and used as a replacement of virgin aggregate in onsite roadwork or used as a replacement for normal weight coarse aggregate in the manufacture of concrete blockwork. 1 ton of crushed clay brick results in a (net) production of 900 kg of recycled secondary aggregate with 100 kg to landfill from crushing. This recycled secondary aggregate can in turn replace 900 kg of virgin aggregate. The ecoinvent v3.2 dataset used to represent avoided impacts of virgin aggregate was: Gravel, crushed {GLO}  market for   Alloc Def, U		



## Interpretation

Figure 1 shows that for the production stage (modules A1 to A3), the majority of the total GWP value arises from onsite energy usage, which includes the use of natural gas, electricity, coal and coke, diesel and LPG fuels. The second highest contributor is from the emissions released from the clay raw materials on firing. The other input processes have relatively low contributions to the total GWP value by comparison.

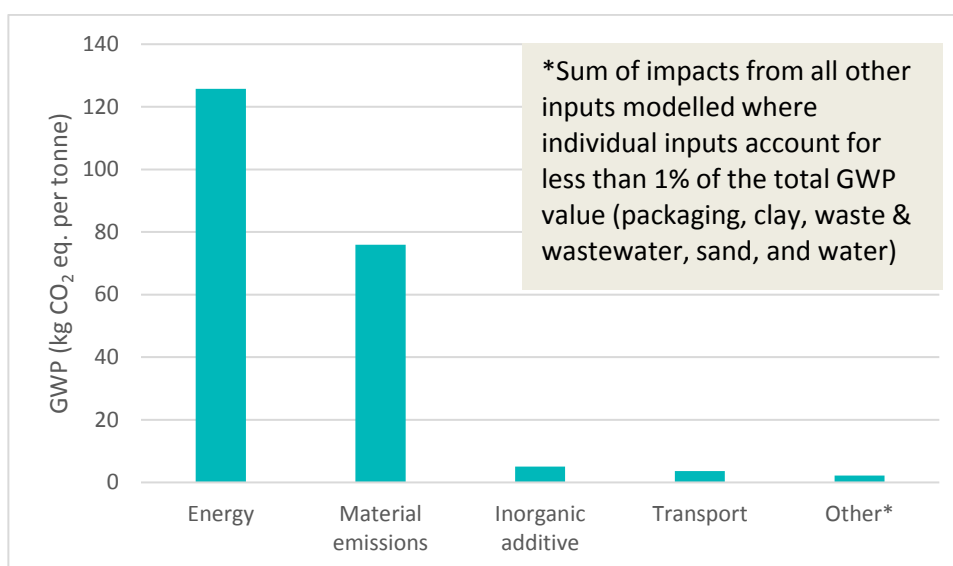


Figure 1: GWP per tonne values by contributing input process

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