Results from the Eco-Serve Network, Task 2

Indicators for Assessing Improvements in the Construction Industry

November 2004

1. Introduction

This report describes some of the result achieved in the Eco-Serve Network.

The Eco-Serve Network is contracted by the European Commission and involves 15 European industries and research institutes.

The Network focuses on the environmental impact of the construction industry exemplified and focused on materials production.

1.1.1 Overall goal

The goal for the network is to develop and disseminate knowledge about new technologies in order to achieve

- 30% reduction in CO_2 emission of the present level (measured on the relevant segment of the industry)
- 20% reduction in hydrocarbon consumption (through reduced need for fuel, bitumen and transportation energy)
- 20% reduction in need for transportation of aggregates for construction
- 20% reduction in construction cost for comparable qualities
- as well as improve working environment and increase productivity/competitiveness/quality.

To assess the improvements all activities in the network has been seen in a life cycle perspective.

1.1.2 Indicators

It has been the goals to define a set of indicators that can show improvements and that also are easy to use and only require available data.

Together with the indicators simple tools for necessary calculations are developed.

1.1.3 More information

More information can be found on the Eco-Serve Network homepage http://www.eco-serve.net/publish/start.shtml. Related articles and a background report is available here.

At the home page information on the technical findings within the Network is also available.

2. Life cycle approach

It has been important to view all the activities in the Eco-Serve network in a life cycle perspective in order to understand how changes in one activity affect the others. Even though focus in ECO-SERVE is on the first life cycle phases.

2.1 Life cycle

In a life cycle approach all activities from cradle (winning of raw materials) to grave (waste management) is included.

A life cycle assessment can be used for either identifying the most important activities with respect to the environment or to compare two different constructions.

For the construction industry the following processes and activities are included:

- Winning of raw materials and processing of these
- Production of materials
- Construction
- Use and maintenance
- Demolition and waste treatment

- and transportation between the sites

The activities in the project are shown in figure 1. The boxes shown in figure 1 illustrate the life cycle steps considered in Eco-Serve.

2.2 Functional unit

As shown in figure 1, the two central units (marked with red colour) are production of 1 m^3 of concrete and construction of 1 m^2 of pavement. The two units are also called functional units.

The functional unit of a product or a construction is defined by the services and qualities it presents. The functional unit for a house may be described by the size (m^2), the durability (in years), the need for maintenance, the architecture and the materials used. For a road the functional unit may include capacity (tonnes per year) durability, need for maintenance and traffic safety. The services, two product provides, have to be the same, if compared.

In figure 1 is also shown what the 4 technical working groups, clusters, are working on.

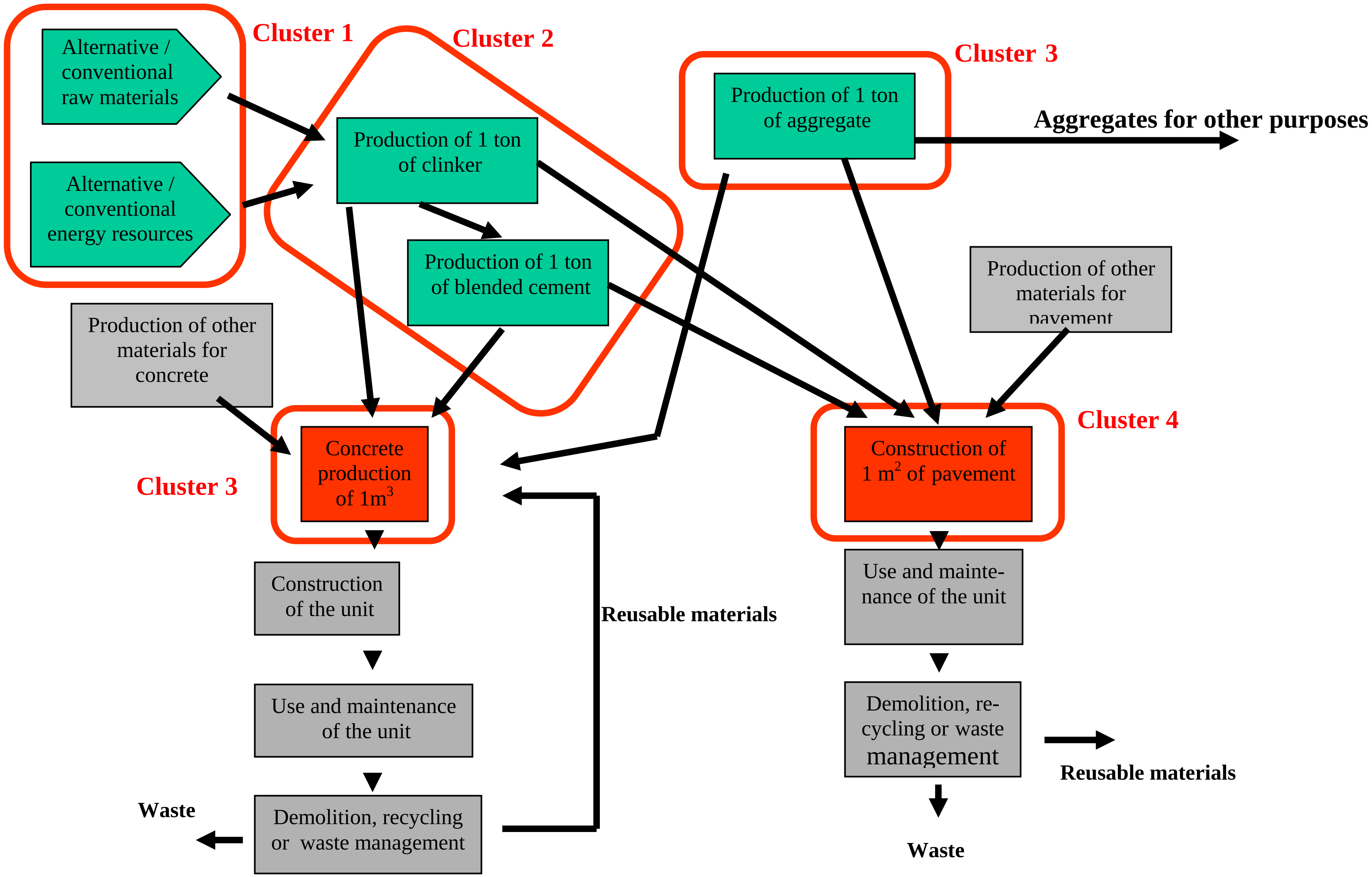

Figure 1: Life cycle thinking in the construction industry

2.3 Activities in the clusters

The goal for cluster 1 is to identify and assess alternative energy sources and materials for clinker production. Changes here may affect the environment at the site of clinker production, and may as well introduce some changes in the cement and concrete production and in the construction of pavement. The environmental impact from leaching may also change during use and demolition of the construction.

Cluster 2 is focusing on the environmental impact from production of blended cement. Changes in composition of blended cement may cause changes in the use of the cement for construction. Durability and leaching during the use of the construction may be affected.

The activities for Cluster 3 is divided into two parts, - one is focusing on production of aggregates and one is focusing on concrete production. Because aggregates are used in large quantities changes in winning and processing will affect the environmental performance of both concrete production and road construction and other pavements.

Cluster 4 is working with pavement for road construction. Here changes in blended cement, use of alternative materials etc. may affect the use by leakage of hazardous substances.

In figure 1 the boxes that are coloured red and green are included in the Eco-Serve project. The grey boxes illustrate the other activities to complete the life cycle approach.

3. Indicators

Assessing changes in environmental performance are often done by using life cycle assessment (LCA). LCA both on a detailed level and in simplified ways requires a relatively substantial amount of data and work.

Indicators as a tool for assessing changes in the environmental performance are chosen because less data is necessary and the calculations simpler. Choosing the right indicators does require basic knowledge about the life cycle. This is available for the construction industry where LCA's has been performed several times.

Changes in one activity may seem important for the specific activity, but compared to the other activities in the life cycle it may play a minor role. An example of this could be the energy consumption for winning aggregates compared to the energy consumption for clinker production.

3.1 General indicators

General indicators mean indicators that are relevant for all clusters and for most activities in the life cycle of constructions. Indictors relevant for Eco-Serve and the construction industry are mentioned.

3.1.1 Energy

Consumption of energy is a key-issue for most activities. Energy is consumed for

- clinker production,
- winning and processing aggregates,
- mixing processes and
- transportation

The use-phase, which for instance includes many years of heating and/or cooling a building, is often the largest energy consumer. This is not included in the considerations of the Eco-Serve project, but can be taken into account.

Different types of energy are used as for example electricity, diesel oil or alternative fuels.

In order to ad these different types of energy together the amount of primary energy is calculated. Primary energy means the total amount of energy spent including losses for transformation etc.

Tools for calculating primary energy are established based on data for consumed electricity, consumed oil and gas for processes and transportation as well as other necessary conversions, - see chapter 4.

3.1.2 Carbon dioxide

Emission of carbon dioxide is another relevant indicator. The amount of carbon dioxide does to some extend picture the amount of consumed energy. Never the less not all sources of energy cause the same amount of carbon dioxide per unit of energy.

In the context of the construction industry, issues as carbon dioxide formed by the clinker production and the use of secondary materials are important activities.

To measure the indicator for carbon dioxide simple tools are developed. The necessary inputs are for example:

- Amount and type of spent energy for transportation and processes
- Amount of clinker content

3.2 Specific indicators

3.2.1 Clinker content

The content of clinker is an important issue in the concrete industry. The production of clinker consumes energy and carbon dioxide is released from the calcination process.

This means that the environmental effects from the clinker production are included in the indicator for carbon dioxide as well as for energy consumption, and therefore, there is no need for a special indicator for the clinker content. Information about the amount of clinker is important data used for calculating the carbon dioxide indicator (see section 4.2).

Blended cement in relation to LCA is a question of the amount of clinker and other materials used and if the blending takes place when producing blended cement or concrete.

3.2.2 Leaching

Leaching of hazardous substances from concrete during use is pointed out as an important parameter.

Hazardous substances may be introduced by using alternative fuels and other materials by production of clinker and by using alternative filler materials for blended cement.

No simple indicator has been developed. Changes in leaching of a set of substances, primarily heavy metals, have to be assessed. The assessment has to include factors as mobility of the substances and toxicity as well as the use of the local area (e.g. ground water interests) and national legislation.

Leaching from two different types of concrete can be compared relatively easily if other circumstances are the same.

3.2.3 Land use

Land use in relation to winning of aggregates has been considered as an indicator, - but a way to measure this in practice has not been found.

3.2.4 Amount of surplus material

When winning of aggregates, fine surplus material can be relevant to consider. If the surplus material can not used for other purposes it has to be regarded as waste.

In indicator for surplus material is:
used material [kg] / total extracted material [kg]

3.2.5 Binder consumption and local aggregates

When producing concrete focus is on binder consumption and local aggregates.

By using the two general indicators, energy and carbon dioxide, a change in the amount of binder will be measured.

Transportation of aggregates is also important. The shorter the distance of transportation is, the smaller amount of energy is consumed. Using local aggregates will therefore be shown in both the indicators for energy and for carbon dioxide.

3.2.6 Recycling of materials

Recycling of demolished material is important in the construction industry. Never the less, an indicator measuring the use and reuse of materials in the whole lifecycle has is not been included in the Eco-Serve activities.

3.2.7 Other environmental issues

Durability could be regarded as an indicator, but durability is very often part of the functional unit, where the service of the product is defined. For instance, if one type A of a road has a durability of 20 years and type B has a durability of 40 years, you have to compare two A with one B to obtain the same service.

3.3 Other indicators

3.3.1 Working environment

The clusters have assessed indicators measuring the performance for the working environment.

Some have found the indicator “work hours lost due to accidents or work related disease per functional unit” relevant.

Indicators measuring the damages from vibrations are relevant considering self compacting concrete and the amount of dust is relevant handling aggregates. These indicators are considered for the relevant activities, but not for whole life cycle in general.

Others have found it very difficult to identify indicators for which data are easily retrieved.

3.3.2 Productivity

The clusters have assessed indicators for productivity, competitiveness and quality.

An indicator expressing productivity in terms on spend man hours per produced unit can be relevant for some activities. Never the less, data can not be expected to be available for the whole life.

Regarding competitiveness cost of materials per construction unit has been considered. Due to confidentiality of most data this indicator seems not to be applicable.

A central indicator for quality is durability expressed by the lifetime of the construction expressed in years. To this comes the necessary maintenance.

4. Tools

For the two general indicators some tools have been developed in order to make it possible to use directly measured data for calculating the indicators.

Regarding pavement special activities has been carried out in order to assess leaching from pavement, but it is not clear weather it is possible to relate this assessment to indicators for the life cycle of concrete.

By directly measured data means for instance:

- Consumed amount of electricity measured in kWh
- Consumed amount of fuel for heating measured in m^3
- Transport distance in km, transported amount in tons and transport mode (truck, rail or ship)

Conversion factors have been gathered both for calculating energy as well as carbon dioxide.

The tools are presented on the Networks web-site. The following is a short presentation these.

4.1 Energy

When data on energy consumption is present the total amount of energy can be estimated based on data given in Table 1. As can be seen the amount of carbon dioxide emitted using average European technology is also given.

Table 1: Content of energy in energy resources

	Raw material	**Energy**	**CO_2-emitted**
Oil	0,275 kg	9,68 MJ	0,88 kg
Gas	0,241 Nm3	6,93 MJ	0,77 kg
Nuclear energy	0,029 gram	9,64 MJ	0 kg
Hard Coal	0,613 kg	9,1 MJ	0,98 kg
Brown Coal	1,48 kg	10,9 MJ	1,35 kg
Hydro	4,7 m^3	1,1 MJ	0 kg

The amount of energy used for transportation can be estimated based on data on transported distance, amount and transport method.

Amount of energy consumed =
distance (km) x weight (ton) x method (MJ/kg x ton)

Data for this based on European average data is show in table 2.

Table 2: Energy consumption for transportation

Method	Energy consumption
Train	0.8 MJ/(kg x ton)
Ship	1 MJ/(kg x ton)
Truck	5 MJ/(kg x ton)

A more detailed description is available in the background report.

4.2 Carbon dioxide

Contributions to emission of carbon dioxide is use of fossil fuels for energy and the release of carbon dioxide in the production of clinker (calcination).

In cluster 2 the relationship between the content of clinker and the amount of carbon dioxide emitted has been presented. This is shown in figure 2.

From figure 2 it can be seen that production of a CEMI with almost 100 percent clinker emits about 0,9 ton CO_2 per ton cement.

Half of the emission originates from the calcination and half from consumed fossil fuels required for heating.

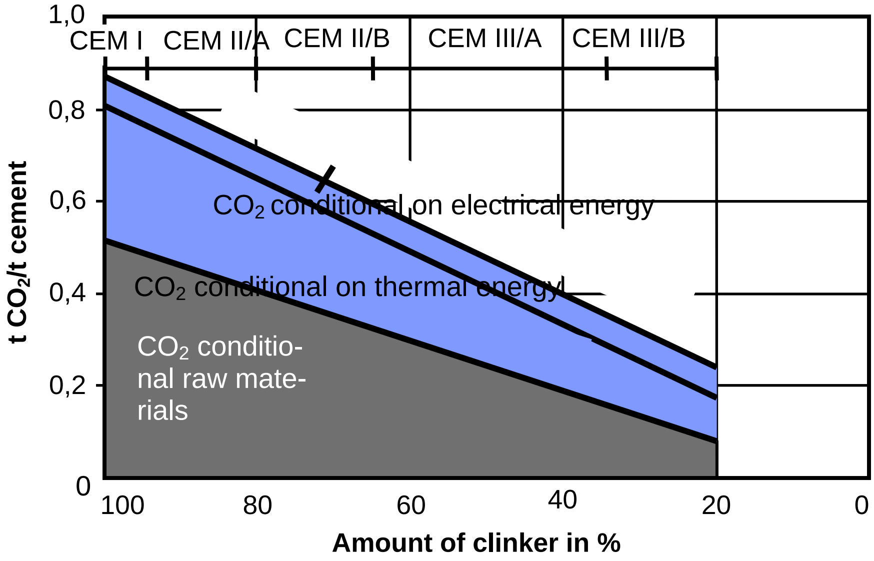

Figure 2 Carbon dioxide emission from blended cement

5. Examples

The carbon dioxide indicator is relevant for assessing the environmental impact of reducing the clinker content in concrete by either using blended cement or by adding cementitious supplementary material to the concrete.

An example of this is shown in the following figures. Figure 3 shows the life cycle for 1 m3 of concrete based on CEMI. The amount of used material is shown in the figure as well as the amount of carbon dioxide emitted from

- the production of clinker,
- from transportation of aggregates,
- other needs for transportation and
- production of concrete.

In figure 4 is shown the same picture, but here the cement content is reduced by 25 percent.

In the last figure, no. 5, is shown how much carbon dioxide, that might be absorbed, if 100 percent carbonisation take place during use of the construction and demolition.

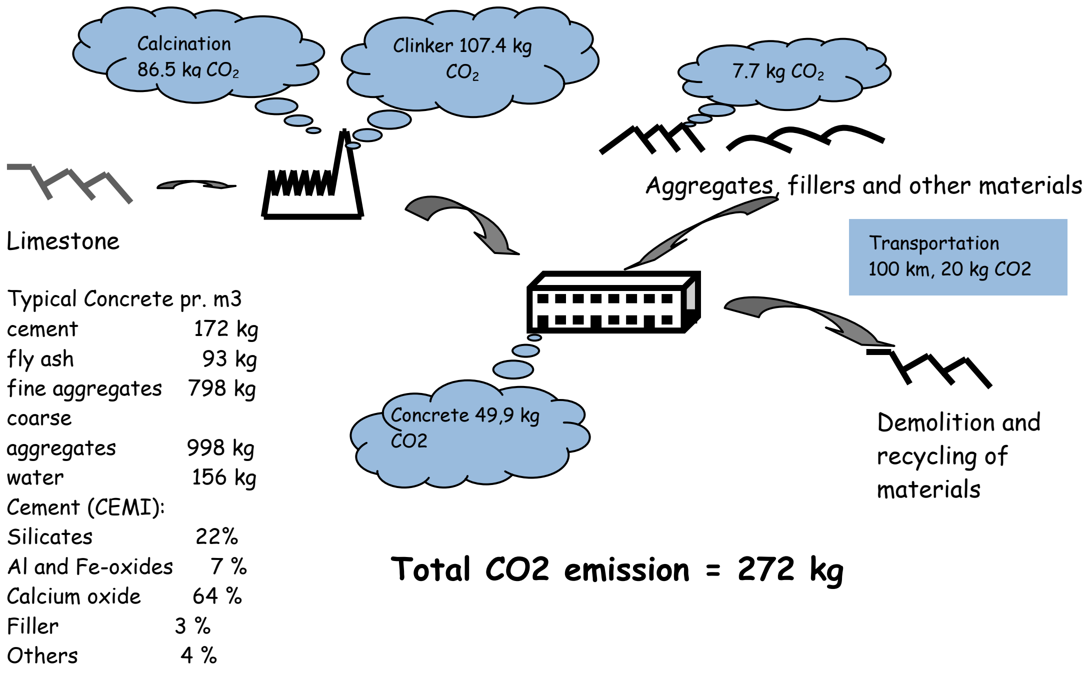

Figure 3: The reference situation

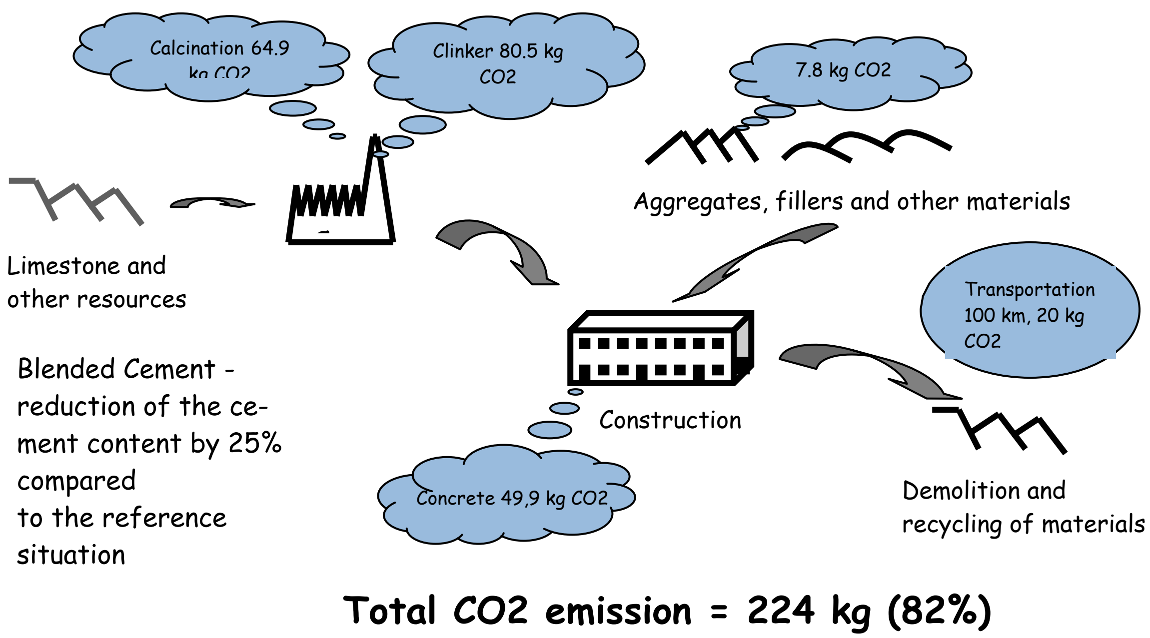

Figure 4: Reduced content of cement

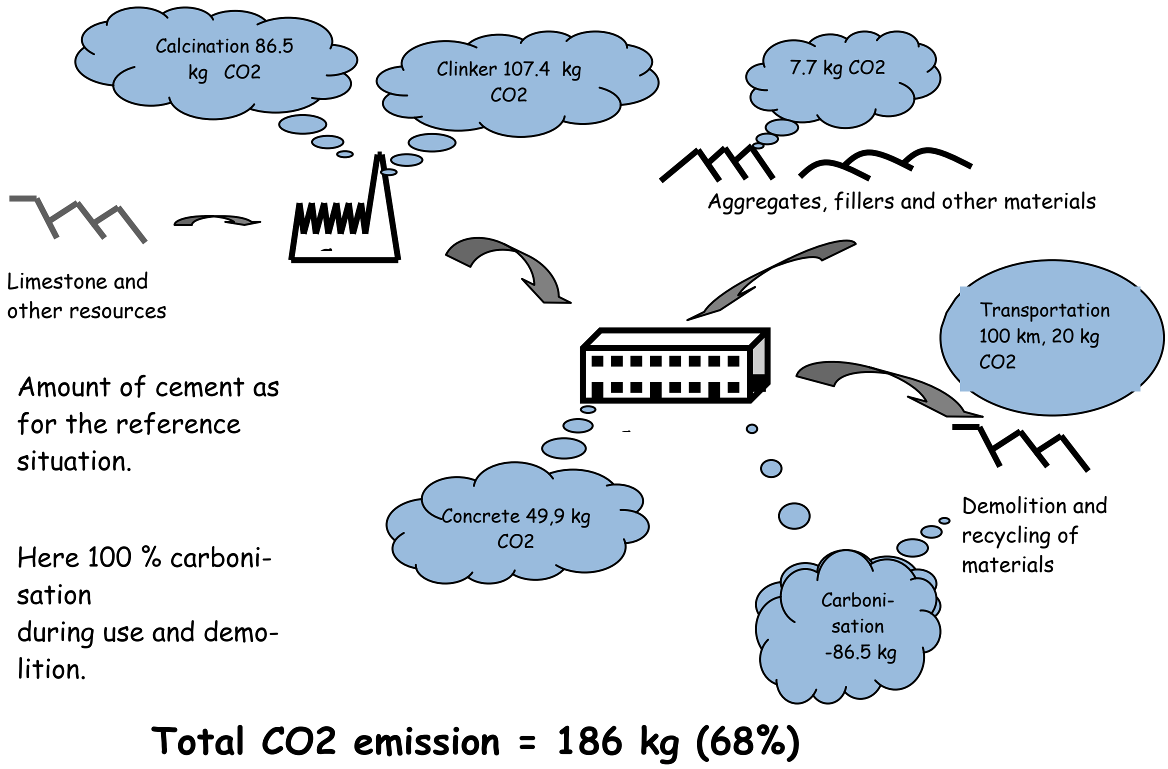

Figure 5: Including carbonisation