

# Technical Datasheet 8.3 (P1)

## Embodied CO<sub>2</sub> of UK cement, additions and cementitious material

### Introduction

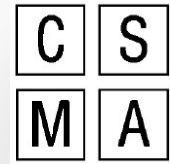
The indicative embodied CO<sub>2</sub> (ECO<sub>2</sub>) for the main cementitious constituents of concrete are shown in Table 1. These figures are derived using data for the calendar year 2007. The figures are 'cradle to factory gate' as they do not include the transport from the place of manufacture of the cementitious material to the concrete plant. ECO<sub>2</sub> figures for a range of factory made cements and their equivalent combinations are given in Datasheet 8.4 [P2] titled '*Embodied CO<sub>2</sub> of factory made cements and combinations*'.

**Table 1. Embodied CO<sub>2</sub> of UK cement, additions and cementitious material**

Cement, additions and cementitious material [Descriptions of the materials are shown overleaf]		Embodied CO <sub>2</sub> (kg CO <sub>2</sub> /tonne)
<b>Portland Cement CEM I</b>		<b>930</b>
<b>Addition or cement constituent</b>	<b>Ground granulated blastfurnace slag (ggbs)</b>	<b>52</b>
	<b>Fly Ash (from coal burning power generation)</b>	<b>4</b>
	<b>Limestone</b>	<b>32</b>
	<b>Minor additional constituent (mac)</b>	<b>32</b>
<b>Weighted Average Cement</b> NOTE 1. This is the weighted average of all CEM I, II, III and IV factory-made cements supplied by BCA Member Companies* in the UK		<b>880</b>
<b>Weighted Average Cementitious</b> NOTE 2. Includes all CEM I, II, III, IV cements, ggbs and fly ash supplied in the UK NOTE 3. The weighted average non-clinker cementitious content in the UK is 23%		<b>720</b>
*BCA's Members are Castle Cement, CEMEX UK, Lafarge Cement UK and Tarmac Buxton Lime and Cement. It is assumed that the material supplied to Northern Ireland is in the same proportion to that supplied in the UK. Materials imported and sold by companies not-manufacturing in the UK are not included.		

### Weighted average cementitious ECO<sub>2</sub>

The Weighted Average Cementitious ECO<sub>2</sub> is the ECO<sub>2</sub> of the individual cementitious materials i.e. CEM I, CEM II, CEM III, CEM IV and additions, weighted by the relative tonnages of each supplied in the UK. It is a representative number to use to assess the ECO<sub>2</sub> of concrete elements at the design stage where it is not possible to identify or specify a particular cement or equivalent combination as shown in Datasheet 8.4 [P2].



The most widely used cementitious materials in the UK are:

<b>CEM I</b>	Portland cement to BS EN 197-1, Cement — Part 1: Composition, specifications and conformity criteria for common cements
<b>Ggbs</b>	Ground granulated blastfurnace slag to BS EN 15167-1 Ground granulated blastfurnace slag for use in concrete mortar and grout — Part 1: Definitions, specifications and conformity, or BS 6699: 1992 Specification for ground granulated blastfurnace slag for use with Portland cement
<b>Fly ash</b>	Fly ash to BS EN 450-1:2005+A1:2007 Fly ash for concrete — Part 1: Definition, specifications and conformity criteria
<b>Limestone</b>	Limestone fines to BS 7979: 2001 Specification for limestone fines for use with Portland cement

Ggbs, fly ash and limestone are additions which are used in combination with CEM I at the concrete plant in accordance with the British Standard for Concrete, BS 8500-2: 2006. These combinations are equivalent to their respective factory-made composite cements, as listed below:

**CEM II S, V, L/LL** Portland-slag, siliceous fly ash and limestone cements

**CEM III** Blastfurnace cement

**CEM IV-V** Pozzolanic cement, siliceous fly ash

CEM IV-V may only be available to special order but its equivalent combination is available. CEM I, CEM II, CEM III and CEM IV factory-made cements contain gypsum to optimise setting properties and may also contain up to 5% minor additional constituents (mac). On average CEM I includes about 1% mac.

### Minor additional constituents (mac)

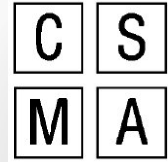
Mac are specially selected, inorganic natural mineral materials, inorganic mineral materials derived from the clinker production process or main constituents such as limestone, ggbs or fly ash. In many cases the  $ECO_2$  figure of the mac could be close to zero as it may be a by-product of the manufacturing process. The most common mac is limestone so the  $ECO_2$  figure is reasonably assumed to be the ground limestone figure at 32 kg  $CO_2$ /tonne. The figure for limestone is estimated from the energy and transport fuel used to grind cement clinker, a necessary assumption as limestone and clinker are generally interground.

### Calcium sulfate

Calcium sulfate is added to the constituents of cement during manufacture to control setting. The calcium sulfate may be gypsum, anhydrite, or hemi-hydrate, or any mixture of them, and may also be a by-product of certain industrial processes. Typically 5% is added to the other constituents of CEM I, CEM II, CEM III or CEM IV in the UK. The  $ECO_2$  associated with the processing and delivery of natural gypsum to where the cement is manufactured is 8.0 kg, and other forms of calcium sulfate such as used-plaster or material from flue gas de-sulfurisation (FGD) are assumed to have the same value.

### Additives

Additives are sometimes used to either improve the manufacture or the properties of cement in accordance with EN 197-1 where the total quantity must not exceed 1.0% and in practice their contribution to overall  $ECO_2$  is not significant.



## Embodied CO<sub>2</sub>

Embodied CO<sub>2</sub> (ECO<sub>2</sub>) is one of a number of Life Cycle Assessment (LCA) factors that may be used to characterise environmental impact of a material or product. The manufacture of cement includes the heating of limestone rich raw materials to a temperature around 1400°C in a kiln, where there is a significant emission of CO<sub>2</sub> associated with the energy required. In addition one of the chemical reactions is calcination, the emission of CO<sub>2</sub> directly from the limestone as it is heated. For this reason ECO<sub>2</sub> is a relevant LCA factor to assess the environmental impact of cement and cement based products. ECO<sub>2</sub> is not the same as Global Warming Potential (GWP) where the GWP value is often expressed as CO<sub>2</sub> equivalent, or CO<sub>2</sub>e. For cement the ECO<sub>2</sub> value includes carbon dioxide attributable to calcination, fuel for combustion, electricity on a primary basis, as well as any fuel or electricity on a primary basis used to deliver raw materials to the cement works or depot, as shown in Table 2.

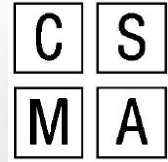
### Cradle to gate inventory of embodied CO<sub>2</sub> with source data

Table 2. Cradle to gate inventory of embodied CO <sub>2</sub> , with source of data						
Manufacturing Process	Ground Clinker	Ggbs	Fly ash	Lime-stone	mac	Gypsum
Calcination	EU ETS BCA	-	-	-	-	-
Combustion	EU ETS BCA	-	-	-	-	-
Primary Electricity for clinker or granulate (includes raw materials)processing	CCA BCA	CSMAe	-	-	-	-
Fuel for drying	-	CCA CSMA	-	-	-	-
Primary Electricity to grind classify/separate.	CCA BCA	CCA CSMA	-	BCAe	BCAe	-
Fuel for raw materials transport	BCAe	CSMAe	UKQAAe	BCAe	BCAe	BGe
<b>Key:</b>						
EU ETS	Regulated and audited under the European Union Emissions Trading Scheme and its monitoring, reporting and verification guidelines					
CCA	Data as audited and verified under the UK Defra Climate Change Agreement for the cement sector					
e	Estimate					
BG	British Gypsum					

## Carbon emission factors

### Cement

Industry specific carbon emissions factors and calorific values are in accordance with the EU ETS Monitoring and Reporting Guidelines, Guidance on Annual Verification v3, February 2007. Where used biomass for combustion is considered 'carbon neutral' under the EU ETS and therefore is not considered to contribute CO<sub>2</sub> to the overall ECO<sub>2</sub> value.



## By-products

In the case of by-products from other industries, such as blastfurnace slag from iron manufacture and fly ash from coal fired power stations, no CO<sub>2</sub> from the primary process is allocated to the by-product. This is because these by-products will arise, irrespective of whether they are used or not. The ECO<sub>2</sub> of ggbs is that attributable to the granulation, transport and processing of blastfurnace slag to make ggbs. Similarly the ECO<sub>2</sub> of fly ash is that attributable to the transport and processing of fly ash to make it into a material suitable for use as an addition in concrete or as a cement constituent.

Where appropriate **ggbs** and **fly ash** manufacturers use 'Guidelines to Defra's conversion factors for company reporting, Annexes updated June 2007' as published by Defra.

## Imported materials

ECO<sub>2</sub> attributable to materials transport to the UK is calculated using estimated distance and UNEP guidelines 'The GHG indicator: UNEP guidelines for calculating greenhouse gas emissions for businesses and non-commercial organisations' published in 2000.

## Which cementitious associations have contributed data to this Datasheet?

This information has been supplied by the following associations and their members:

<b>BCA</b>	British Cement Association, <a href="http://www.cementindustry.co.uk">www.cementindustry.co.uk</a>
<b>CSMA</b>	Cementitious Slag Makers Association, <a href="http://www.ukcsma.co.uk">www.ukcsma.co.uk</a>
<b>UKQAA</b>	UK Quality Ash Association, <a href="http://www.ukqaa.org.uk">www.ukqaa.org.uk</a>

NOTE 1. This Datasheet is available on the above websites

NOTE 2. The information in this Datasheet, together with general sustainability information, is also available on [www.sustainableconcrete.org.uk](http://www.sustainableconcrete.org.uk)

## Where can I find out more?

For product-specific information, contact:

Dr Chris A Clear	BCA
Dr Denis D Higgins	CSMA
Dr Lindon K A Sear	UKQAA

In general usage the term 'fly ash' is used for pulverized coal ash but it can also cover ash from burning other materials. Such 'fly ash' may have significantly differing properties and might not offer the same advantages as ash from burning pulverized coal. UKQAA datasheets only refer to PFA / fly ash produced from the burning of predominantly coal in power stations.

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