



Fact Sheet 18 [P1]

Embodied CO₂ of UK cement, additions and cementitious material

Introduction

The indicative embodied CO₂ (ECO₂) 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. ECO₂ figures for a range of factory made cements and their equivalent combinations are given in Fact Sheet 18 [P2] titled ‘Embodied CO₂ of factory made cements and combinations’.

Table 1. Embodied CO₂ of UK cement, additions and cementitious material		
Cement, additions and cementitious material [Descriptions of the materials are shown overleaf]		Embodied CO₂ (kg CO₂/tonne)
Portland Cement CEM I		930
Addition or cement constituent	Ground granulated blastfurnace slag (ggbs)	52
	Fly Ash (from coal burning power generation)	4
	Limestone	32
	Minor additional constituent (mac)	32
Weighted Average Cement 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		880
Weighted Average Cementitious 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%		720
*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 ECO₂

The Weighted Average Cementitious ECO₂ is the ECO₂ 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 ECO₂ 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 Fact Sheet 18 [P2].

The most widely used cementitious materials in the UK are:

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

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 ECO₂ 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 ECO₂ figure is reasonably assumed to be the ground limestone figure at 32 kg CO₂/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 ECO₂ 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 desulfurisation (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 ECO₂ is not significant.

Embodied CO₂

Embodied CO₂ (ECO₂) 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 CO₂ associated with the energy required. In addition one of the chemical reactions is calcination, the emission of CO₂ directly from the limestone as it is heated. For this reason ECO₂ is a relevant LCA factor to assess the environmental impact of cement and cement based products. ECO₂ is not the same as Global Warming Potential (GWP) where the GWP value is often expressed as CO₂ equivalent, or CO₂e. For cement the ECO₂ 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 CO₂ with source data

Table 2. Cradle to gate inventory of embodied CO₂, 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	UKQA Ae	BCAe	BCAe	BGe
Key:						
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 CO₂ to the overall ECO₂ 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 CO₂ 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 ECO₂ of ggbs is that attributable to the granulation, transport and processing of blastfurnace slag to make ggbs. Similarly the ECO₂ 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 **ggb**s and **fly ash** manufacturers use ‘*Guidelines to Defra’s conversion factors for company reporting, Annexes updated Jun 2007*’ as published by Defra.

Imported materials

ECO₂ 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 Fact Sheet?

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

BCA British Cement Association, www.cementindustry.co.uk

CSMA Cementitious Slag Makers Association, www.ukcsma.co.uk

UKQAA UK Quality Ash Association, www.ukqaa.org.uk

NOTE 1. This Fact Sheet is available on the above websites

NOTE 2. The information in this Fact Sheet, together with general sustainability information, is also available on www.sustainableconcrete.org.uk

Where can I find out more?

For product-specific information, contact:

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Document No: ST/FS/18 [P1]	Revision No: 0
Authors: BCA, CSMA and UKQAA	Drafted: 12 February 2009
	Last revised: