Fact Sheet 18

Embodied CO_2e of UK cement, additions and cementitious material

1 Introduction

The information in this fact sheet is aimed at providing lifecycle[1] data to inform 'carbon footprinting' in the concrete supply chain. This fact sheet replaces a previous version which was based on 2010 data and reflects greenhouse gas reductions achieved by the sector. It includes all greenhouse gases converted to a CO_2 equivalent basis (CO_2e).

The indicative CO_2e for the main cementitious constituents of concrete are shown in Table 1. Data are 'cradle to factory gate', so transport from the place of manufacture of the cementitious material to the concrete plant is not included.

Table 1: CO_2e of UK cement, additions and cementitious material

Cement, additions and cementitious material [Descriptions of the materials are shown below]	**CO_2e**	
Portland Cement CEM I: cradle to factory gate	**860**[2]	**kg CO_2e/tonne CEM I**
	(From cradle to leaving the factory gate of the addition manufacturer)	
Ground granulated blastfurnace slag (ggbs)	**79.6**[3]	**kg CO_2e/tonne GGBS**
Fly Ash (from coal burning power generation)	**0.1**[4]	**kg CO_2e/tonne Fly Ash**
Limestone Fines	**8.0**[5]	**kg CO_2e/tonne Limestone**
Weighted Average Cement (see Note 1). This is the weighted average of all factory-made cements supplied by MPA Cement Member Companies in the UK.	**820**	**kg CO_2e/tonne cement**
Weighted Average Cementitious: cradle to factory gate (see Note 2). Includes all CEM I, II, III, IV cements, ggbs and fly ash supplied in the UK.	**668**	**kg CO_2e/tonne cementitious**

Note 1: MPA Cement members are Breedon, CEMEX, Hanson, Lafarge Cement and Tarmac. Materials imported and sold by companies not manufacturing in the UK are not included.
Note 2: The Weighted Average Cementitious CO_2e is the CO_2e 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 address the CO_2e 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 Tables 3 and 4 below.

[1] This Fact Sheet has been designed to be compatible with the principles of standard ISO 14067 to provide a cradle to gate 'partial carbon footprint' as defined in that standard.
[2] MPA Cement 2018 data collected from all UK plants and converted using UK Greenhouse Gas Emission Factors (https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting)
[3] Taken from Hanson Environmental Products Declaration for GGBS, 2019, https://www.hanson.co.uk/en/system/files_force/assets/document/53/9b/environmental-product-declaration-hanson-concrete-c28-35-cemi.pdf?download=1
[4] Provided by UK Quality Ash Association in 2019
[5] G. Bolte, M. Zajac, J. Skocek, M.B. Haha, "Development of composite cements characterized by low environmental footprint", Journal of Cleaner Production 226 (2019) 503-214.

Cementitious materials available for use in the UK are:

Cement	Cement to BS EN 197-1, Cement — Part 1: *Composition, specifications and conformity criteria for common cements*
Ggbs	Ground granulated blastfurnace slag to BS EN 15167-1 Ground granulated blastfurnace slag for use in concrete mortar and grout — Part 1 Definition, specifications and conformity criteria
Fly ash	Fly ash to BS EN 450-1 Fly ash for concrete — Part 1: *Definition, specifications and conformity criteria*
Limestone	Limestone fines to BS 7979 *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 works in accordance with the British Standard for Concrete, BS 8500-2. These combinations are equivalent to the respective factory-made composite cements listed below:

CEM II/A or B-S, V, -L or -LL	Portland-slag, siliceous fly ash and limestone cements
CEM III/ A, B or C	Blastfurnace cement
CEM IV/B-V	Pozzolanic cement, siliceous fly ash

Note: CEM IV/B-V may only be available to special order but its equivalent combination is available from a concrete plant.

2 Embodied CO_2 of factory-made cements and combinations

The CO_2e for factory made cements and combinations that are commonly available in the UK are shown in Tables 2 and 3 respectively. The data in this fact sheet does not include the transport of materials to the concrete plant and this should be added by the concrete manufacturer in order to determine the CO_2e for material delivered to a specific concrete plant.

Table 2: CO_2e of factory made cements

Cement[a] (Factory made cement)	**Secondary Main Constituent (smc)**[6]	**CO_2e**[b] **Includes transport of all constituent materials to the cement works but not transport to concrete plant (this should be added as shown in section 3.1 below)**
	Low – High Content (%)	**smc content Low – High, (kg CO_2e/tonne)**
CEM I Portland Cement		**860**
CEM II/A-LL or L Portland Limestone Cement	**6 - 20 (limestone)**	**842 - 721**
CEM II/A-V Portland fly-ash cement	**6 - 20 (fly ash)**	**825 - 686**
CEM II/B-V Portland fly-ash cement	**21 - 35 (fly ash)**	**694 - 555**
CEM II/B-S Portland slag cement	**21 - 35 (ggbs)**	**712 - 585**
CEM III/A Blastfurnace cement	**36 - 65 (ggbs)**	**594 - 350**
CEM III/B Blastfurnace cement	**66 - 80 (ggbs)**	**359 - 232**
CEM IV/B-V Pozzolanic (siliceous fly ash) cement	**36 - 55 (fly ash)**	**564 - 381**

a For CEM I, 4% mac and 5% gypsum is assumed. For CEM II, CEM III and CEM IV at the highest proportion of the smc it is assumed that 2% mac is incorporated and at the lowest proportion of smc it is assumed that mac is added at 4% with the appropriate proportions of fly ash and ggbs (as the mac used in the UK is limestone based, there is none added to CEM II/A-LL or L cements).

b CO_2e figures for CEM II, CEM III and CEM IV are based on the range of smc proportion, where the range is from the minimum to maximum proportion of smc. CO_2e can be interpolated for proportions of smc between the minimum and maximum, noting that the minimum CO_2e is associated with the highest proportion of smc

c Please note that not all the cements shown in this table are currently available in the UK.

[6] Secondary Main Constituents or smc are cementitious materials that are added to clinker or CEM I to produce CEM II, CEM III and CEM IV type cements.

Table 3: CO_2e of combinations produced at the concrete works.

Combination[a] (CEM I and addition combined at concrete plant)	Addition	CO_2e[b] Includes transport of all constituent materials to the additions works but not transport to concrete plant (this should be added as shown in section 3.1 below)
	Low - High Content (%)	Addition content Low - High, (kg CO_2e/tonne)
CIIA-LL or L	6 - 20 (limestone)	825 - 690
CIIA-V	6 - 20 (fly ash)	825 - 689
CIIB-V	21 - 35 (fly ash)	694 - 561
CIIB-S	21 - 35 (ggbs)	713 - 593
CIIIA	36 - 65 (ggbs)	596 - 364
CIIIB	66 - 80 (ggbs)	362 - 249
CIVB-V	36 - 55 (fly ash)	564 - 390

a For *combinations* the CO_2e figure for CEM I is used together with the figures for limestone, fly ash and ggbs in the appropriate proportions

b CO_2e figures for CII, CIII and CIV are based on the range of addition proportion, where the range is from the minimum to maximum proportion of the addition. CO_2e can be interpolated for proportions of addition between the minimum and maximum, noting that the minimum CO_2e is associated with the highest proportion of addition

c Please note that not all the combinations shown in this table are currently available in the UK.

3 Transport

Equations to Include Transport to the Concrete Works in CO_2e

The data in this fact sheet does not include any transport of materials to the concrete plant and this should be added by the concrete manufacturer in order to determine the CO_2e for material consumed at the concrete plant. UK Government emission factors[7] can be used to do this if the mode of transport/vehicle and distance travelled are known.

[7] Government emission conversion factors for greenhouse gas company reporting, https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

4 Interpolation of CO_2e in Tables 2 and 3

As stated in the footnotes to Tables 2 and 3, values may be interpolated. For example:

CEM II/A-LL declared by the manufacturer at 15% limestone is: 738 kg CO_2/tonne

NOTE. That is the difference between the high and low CO_2e figures for CEM II/A-LL (825 - 690 = 135) is divided by the high and low difference in proportions (20 – 6 = 14) giving 131 ÷ 14 = 9.6 per 1%. 15% limestone is 5% lower than 20% so the CO_2e value is higher: 690 + (5 x 9.4) = 738 kg CO_2/tonne to the nearest tonne.

Similarly:

CEM II/B-V declared by the cement manufacturer at 30% fly ash is: 609 kg CO_2/tonne

CEM III/A declared by the cement manufacturer at 40% ggbs is: 564 kg CO_2/tonne

CEM III/A declared by the cement manufacturer at 50% ggbs is: 484 kg CO_2/tonne

CEM III/B at 70% ggbs is: 330 kg CO_2/tonne

The same interpolations can be applied for combinations (Table 3) produced at the concrete works.

5 Carbon emission factors and allocation

5.1 General

Emissions of CO_2e in the generation and transmission of electricity were calculated using the Government emission conversion factors for greenhouse gas company reporting[7].

Data on transport of raw materials and kiln fuel was collected by MPA and other contributing associations and converted using the Government emission conversion factors for greenhouse gas company reporting[7]. The factors used included emissions associated with extraction and processing of the fuels.

5.2 Cement

Higher accuracy industry specific carbon emission factors and calorific values in accordance with the EU ETS Monitoring and Reporting Guidelines[8] have been used. Biomass for combustion is considered 'carbon neutral' under the EU ETS and therefore is not considered to contribute CO_2e to the overall CO_2e value.

5.3 By-products

No CO_2e from the primary processes has been allocated to either blast furnace slag from iron manufacture or fly ash from coal fired power stations. This is on the basis that these materials will arise, irrespective of whether they are used or not. EN 15804[9] has been used as guidance and under this standard, processes contributing of the order of 1% or less to the overall revenue are allowed to be neglected for the purposes of allocation. An estimate based on UK data concluded that the revenue from blastfurnace slag relative to the total revenue (iron + slag) was only of this order and that allocation was therefore not necessary.

[8] EU ETS Monitoring and Reporting Guidelines, https://www.gov.uk/guidance/participating-in-the-eu-ets

[9] EN 15804 "*Sustainability of construction works- Environmental product declarations- Core rules for the product category of construction products*".

5.4 Imported materials

CO_2e attributable to materials transport to the UK is calculated using distance data collected by MPA Cement and the UK Government GHG Conversion Factors for Company Reporting[7]. Data concerning imported materials by non-manufacturers (independent importers) is not included in this fact sheet.

6 Where can I find out more?

For information on the methodology used in this fact sheet please contact Dr R. Leese (Richard.Leese@mineralproducts.org) or Dr D. Casey (Diana.Casey@mineralproducts.org) at MPA.

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