UK CONCRETE INDUSTRY SUSTAINABLE CONSTRUCTION STRATEGY

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Abstract

The UK Government has set aspirational sustainability targets. As a consequence there has been repeated revision of UK Building Regulations to improve the performance with respect to the conservation of fuel and power. There is also widespread use of ‘voluntary’ environmental assessment schemes that incentivise the use of the lower embodied CO_2 options for building elements. Specific CO_2 limits have not been set for infrastructure but Government agencies have developed carbon calculators to establish benchmarks and for use as part of scheme selection.

I response to these developments the UK Concrete Industry has developed a Sustainable Construction Strategy. At the vanguard is communication with clients to provide knowledge of concrete solutions for a sustainable built environment. In addition there is engagement with the supply chain to inform good practice and explore ways of improving sustainable production.

Keywords

BREEAM, Durability, Carbon calculators, Responsible sourcing, Sustainability, Targets, Water, Zero Carbon.

Biographical notes

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Dr Chris A Clear became Technical Director of the British Ready-Mixed Concrete Association (BRMCA) in 2010. This role is to coordinate industry input into various European and British Standards as well as generate and approve technical and marketing literature for use by industry. Chris spent the early part of his career (1980-1989) in Research and Development at the Cement and Concrete Association, which then became the British Cement Association. Later (1989-2003) he held Technical and Marketing roles for Civil and Marine Slag Cement Limited before returning to the British Cement Association (BCA) in 2003 as Research Manager. The Quarry Products Association (QPA), which included BRMCA, merged with BCA and The Concrete Centre (TCC) to become the Mineral Products Association (MPA) in 2009. Chris is a member of CEN SC1 TC 104 TG17 on Equivalent Durability Performance, Joint Working Group CEN TC 51/104 WG 12 TG5 on Durability Testing as well as on a number of UK Concrete Standards Committees.

1. INTRODUCTION

The UK Government has set its own series of sustainability targets, where these go way beyond the EU in terms of policy commitments. In particular the UK has set a carbon budget of a 34% reduction by 2022 and 50% by 2027 compared to the 1990 baseline. Around 37% of UK emissions are attributed to the heating and power consumption of homes and buildings and so these have been identified as a prime area for improvement. This is being addressed through the UK Building Regulations and further encouraged by demanding requirements for any Government supported affordable housing. Although the emissions target are largely being dealt with by regulations covering the in-use performance of buildings there are 'optional' requirements pertaining to the embodied CO_2 of the construction materials themselves. These optional requirements are not always as optional as they appear because local planning authorities have the power to make them conditional for consent to be granted. For infrastructure projects the responsible Government agencies have developed carbon calculators, and although limits have not yet been set on any project data is being collected and may form part of the scheme selection criteria and be the basis on which benchmarks are set. Under these types of regulatory and non-regulatory pressures it makes sense for the Concrete Industry to develop and support its own Sustainable Development Strategy to ensure that it is seen as a leader in sustainable construction, taking a dynamic role in delivering a sustainable, low carbon built environment in a socially, environmentally and economically responsible manner.

2. UK SUSTAINABILITY DRIVERS

2.1 UK Government Carbon Plan

The UK Government published its revised Carbon Plan in December 2011[1], which confirmed the UK commitment (The Climate Change Act 2008) and a carbon budget framework. The Climate Change Act established a legally binding target to reduce the UK's greenhouse gas emissions by at least 80% below base year levels by 2050, to be achieved through action at home and abroad. The base year is 1990 for carbon dioxide, nitrous oxide and methane, and 1995 for hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. To drive progress and set the UK on a pathway towards this target, the Act introduced a system of carbon budgets which provide legally binding limits on the amount of emissions that may be produced in successive five-year periods, beginning in 2008. The first three carbon budgets were set in law in May 2009 and require emissions to be reduced by at least 34% below base year levels in 2020. The fourth carbon budget, covering the period 2023–27, was set in law in June 2011 and requires emissions to be reduced by 50% below 1990 levels but this is to be reviewed in 2014 in light of EU Emissions Trading System cap. The UK Carbon Budget 2008 to 2027 is summarized in Table 1.

Table 1 UK Carbon Budget 2008 to 2027

	First carbon budget (2008–12)	Second carbon budget (2013–17)	Third carbon budget (2018–22)	Fourth carbon budget (2023–27)
Carbon budget level (million tonnes carbon dioxide equivalent ($MtCO_2e$))	3018	2782	2544	1950
Percentage reduction below base year levels	23%	29%	35%	50%

This Carbon Plan sets out the proposals and policies for meeting the first four carbon budgets, where the report notes that in 2009 37% of UK emissions were produced from heating and powering homes and buildings. By 2050 all buildings will need to have an emissions footprint close to zero. Buildings will need to become better insulated, use more energy-efficient products and obtain their heating from low carbon sources.

2.2 Zero carbon homes

The definition of zero carbon was originally envisaged to be Level 6 of the Code for Sustainable Homes[2], where this is designated the 'Zero Carbon Home' (ZCH). A summary of the minimum standards for the various levels is shown in Table 2.

Table 2. Minimum standards for sustainable homes

	Code Level					
Category	**1** ★	**2** ★★	**3** ★★★	**4** ★★★★	**5** ★★★★★	**6** ★★★★★★
1. Energy/ CO_2	Target Emission Rate (TER) below 2006 Building Regulations[3]					Zero carbon in use
	10%	18%	25%	44%	100%	
2. Water use, litres/person /day	120	120	105	105	80	80
3. Materials, environmental impact	At least 3 of the 5 key elements of construction are specified to achieve a BRE Green Guide 2006[4] Rating of at least D. i) roof structure and finishes, ii) external walls, iii) upper floor, iv) internal walls, v) windows and doors					
4. Surface Water Run-off	Ensure that peak run-off rates and annual volumes of run-off will be no greater than the previous conditions of the development site					
5. Waste	Site waste management plan, targets and monitoring to promote resource efficiency					
	Where there is adequate space then EITHER: Accommodation of all external containers provided by Local Authority OR At least 0.8 m^3 per dwelling for waste management to BS 5906 Code of practice for storage and on-site treatment of solid waste from buildings.					

Both the code for sustainable homes and the building regulations are regularly revised, and there is some confusion as the 2010 set of building regulations mandate that the Code Level 3 home in terms of conservation of fuel and power are the minimum required. Indeed there is a real consideration that the uplift requirements for sustainable homes will be made part of the building regulations themselves.

In the context of the Code for Sustainable Homes a 100% reduction in energy use for Level 5 just refers to the energy covered by building regulations, i.e. heating, hot water, ventilation and lighting. The Zero Carbon for Level 6 refers to all energy used in the home. Table 2 only sets out the minimum standard, that is an entry level. To achieve a code level then there are additional requirements, where the points required from additional items range from 72% of the Total requirement for Level 6 to 92.5% for Level 1, where a summary is shown as Table 3.

Table 3. Points required for sustainable homes

		Code Level					
Points		**1** ★	**2** ★★	**3** ★★★	**4** ★★★★	**5** ★★★★★	**6** ★★★★★★
Entry Level	Energy	1.2	3.5	5.8	9.4	16.4	17.6
	Water	1.5	1.5	4.5	4.5	7.5	7.5
Other points required		33.3	43.0	46.7	54.1	60.1	64.9
Total Points		36.0	48.0	57.0	68.0	84.0	90.0

The ZCH definition largely refers to the operational use of the building, but under category 4 materials there are requirements for some of the building elements where a minimum Green Guide[4] Rating of at least D is required for the five named elements.

The calculation of Green Guide rating is a sophisticated procedure that starts by calculating the quantity of materials incorporated into the functional units of particular building elements, per m^2 and over a generic 60 year study period. For the Code for Sustainable Homes the five building elements initially considered are:

- External walls
- Internal walls and partitions
- Roofs
- Ground and upper floors
- Windows

The quantities of materials are then combined with the environmental impact data of each across 13 categories:

- Climate change
- Water extraction
- Mineral resource extraction
- Stratospheric ozone depletion
- Human toxicity
- Ecotoxicity to Freshwater
- Nuclear waste (higher level)
- Ecotoxicity to land
- Waste disposal
- Fossil fuel depletion
- Eutrophication
- Photochemical ozone creation
- Acidification

The environmental impact data is made available as a BRE Environmental Profile, where part of this profile may be described as an Environmental Product Declaration as it quantifies the impact of each category. However, the BRE Environmental Profile goes further in that the numbers are weighted and combined to give a BRE Ecopoints Score (Ecopoints Scores are not the same as CSH credits).

A rating is formed by dividing the range of scores given to all the different types of each building element into six equal parts, where A+ represents the best environmental performance or least environmental impact, and E the worst environmental performance or greatest environmental impact. Where an element is A+ it is deemed to score 3, A =2, B = 1 but C, D or E score 0. These are interim scores and should not get confused with CSH points, where CSH points achievable are summarized in Table 4, where the additional points for responsible sourcing of materials available are included.

Table 4. CSH Points for materials

Issue	Measurement criteria		CSH Credits
Environmental impact of materials	If all five building elements are rated A+ at 3 points each then a maximum 15 points is scored	≥3	0.9
		≥6	1.8
		≥9	2.7
		≥12	3.6
		15	4.5
Responsible sourcing of materials – basic elements	Where materials used in key building elements are responsibly sourced (e.g. timber certification, EMS)		Between 0.3 to 1.8*
Responsible sourcing of materials – finishing elements	Where materials used in secondary building and finishing elements are responsibly sourced (e.g. timber certification, EMS)		Between 0.3 and 0.9*
* for Detail see Technical Guidance Manual[5]			

The point score for responsible sourcing was originally only available for timber under the Forestry Stewardship Council (FSC)[6] as there was no equivalent scheme available to the concrete industry. This position has changed since the publication of a BRE Environmental & Sustainability Standard for Responsible sourcing[7] followed by a British Standard[8]. These Standards are framework standards in that they contain a general requirement to establish key performance indicators and further guidance is needed to incorporate the particular characteristics of each materials sector, such as the concrete sector[9].

It has to be emphasised that all levels of the Code for Sustainable Homes are by definition above the minimum requirements for UK Building Regulations, although the recent changes mean that a level 3 home in terms of fuel and power conservation is the minimum standard. At this level it is interesting to note that of 57.0 points required a maximum of 7.2 points are available from materials choices, i.e. about 13%

To date the ‘Zero carbon home’ has only been achieved in practice by a handful of exemplar schemes. The definition presents considerable difficulties not least because it treats every home as an individual energy ‘island’ which must generate all the power and heat it needs. For example each house would need to generate its own energy either from heat pumps, wind turbines or photovoltaic panels.

The UK Homes and Community Agency (HCA) provides land and funding for affordable housing, and there has been a requirement that such developments should meet level 3. This represents a 25% improvement from the level set by the Building Regulation 2006 Part L1A requirements. The improvement may be increased to the Code level 4 requirement of 44% in

2013 as an interim measure before setting a carbon compliance level for the range of dwellings to be effective from 2016., and these are summarised in Table 5.

Table 5. Zero carbon home from 2016

	Low-rise Apartment Block, average per unit	Mid-terrace house	End terrace house	Detached house
Carbon Compliance level* $kgCO_{2(eq)}/m^2/year$	14	11	11	10
* In addition to meeting the CO_2 targets 2016 compliance will also require that the fabric performance requirements specified in the Fabric Energy Efficiency Standard (FEES) for zero carbon homes, these are currently set at 39 $kWh/m^2/year$ for apartment blocks and mid-terrace houses, and 46 $kWh/m^2/year$ for semi-detached, end of terrace and detached houses.				

In the UK it is the Government support for the Code for Sustainable Homes and the push for for the 'Zero Carbon Home' that is a prime reason that the Concrete Industry needs a sustainability strategy. Although the most obvious immediate requirement is to reduce the in use emissions from housing, there are also requirements pertaining to the building fabric. As there are only a minority of points for materials choice available and the materials for foundations are not included in the point system, then it may be tempting to conclude that sustainability is not an issue that should be of concern to the ready-mixed concrete industry. However, this is not the case in the UK where the Government lead initiatives with respect to sustainable homes is having a significant effect. Although only a small proportion of new homes are required to meet the CSH Level three target, and of the requirements there is only a small proportion of points pertain to materials, of these points there is only a maximum of 2.7 points out of 57.0 for responsible sourcing – it has meant that for commercial reasons 94% of BRMCA ready-mixed concrete production has had to achieve resposible sourcing certification. The point being that when there is so little work to tender for then it is not worth being excluded for the want of Responsible Sourcing Certification.

2.3 Other environmental assement rating systems

For non-domestic buildings the main environmental assessment rating system is BREEAM[10], and although there is little regulatory pressure to construct to BREEAM standards there is considerable market pressure to do so. This is from prospective clients who want to demonstrate their own sustainability credentials by ensuring that flagship offices are perceived as not only well designed but are as environmentally friendly as possible. There are other environmental assessment systems, including LEED[11], DGNB[12] and HQE[13].

A recent survey by the Royal Institute of Chartered Surveyors[14] confirmed the number of commercial buildings in Europe certified by either DGNB, BREEAM, LEED or HQE. Table 6 is a summary of the 'sustainability' certified commercial buildings in Europe up to May 2011.

Table 6 Summary of certified commercial buildings in Europe, May 2011

		Environmental Assessment System				
Country		DGNB	LEED	BREEAM	HQE	Total
A	Austria	6		1		7
B	Belgium		1	9	4	14
CH	Czech Republic		2			2
D	Germany	171	9	6		186
E	Spain		12	3		15
F	France		1	15	579	595
FL	Finland		9			9
GB	United Kingdom		8	~4000		4008
H	Hungary		2	3		5
I	Italy		5	5		10
L	Luxemburg	5		1	3	9
NL	Netherlands		2	8		10
P	Portugal		1			1
PL	Poland		4	3		7
RUS	Russia		1	1		2
S	Sweden		4	3		7
TR	Turkey		5	3		8
TOTAL		182	66	4061	586	4895

From Table 6 it is clear that the UK has considerably more certified commercial building than any other country in Europe. This is likely to be largely attributable to the UK Building Research Establishment being the first to develop an environmental assessment system for commercial buildings, BREEAM was formulated as long ago as 1990, as well as the general market pressure. Although the numbers of certified commercial building are small compared to the total building stock it is evident that it is an aspect of increasing importance.

2.4 UK Carbon Calculators

The UK Highways Agency (HA) has set up a Carbon Accounting Framework. The Highways Agency is a UK leader in the construction sector wants to lead by example so it has provided its supply chain with the tools necessary to measure greenhouse gas emissions, and provide the incentives to actively manage, and reduce these, wherever possible. However, before the Highways Agency can set about implementing new measures to reduce its emissions it is first necessary to establish and quantify current greenhouse gas emission levels. To achieve this, data will be gathered from across the Agency and our supply chain to populate the HA Carbon Calculation Framework.

The HA developed a carbon calculation methodology such that their business and supply chain have a consistent and transparent methodology for collecting and calculating their carbon emissions. They intend to use the data to calculate an annual carbon footprint for the Highways Agency, including maintenance, construction and operational (office and travel) activities. As part of this exercise the HA Major Projects in construction, Managing Agent and Design Build Finance and Operate (DBFO) contractors will complete the relevant spreadsheet and provide a quarterly returns on the carbon emissions associated with the work they carry out on behalf of the Highways Agency. The requirements for this are laid out in Interim Advice Note No 114/08[15].

Similarly, the UK Environment Agency[EA] has developed a Carbon Calculator tool[16] to help them to increase their resource efficiency and reduce the carbon emissions associated with their construction projects. It also helps to assess and compare the sustainability of different design options at the appraisal stage and highlight the 'big win' carbon savings for specific construction projects.

The tool was developed with their own construction activities in mind (predominantly fluvial and coastal construction projects). A number of case studies have already been published where: Dymchurch Frontage A quotes the use of fly-ash as part of the cement in concrete to save around 7500 tonnes of CO_2, Nottingham left bank using in-situ trench mix to replace steel sheet piles assessed as a 1900 tonnes of CO_2 saving. However, other construction clients, contractors and consultants may find it useful when assessing their own activities.

Like the Highways Agency the Environment Agency has yet to specify a maximum carbon limit for any scheme but they have introduced a tool to calculate numbers on specific projects.

3. UK CONCRETE INDUSTRY SUSTAINABLE CONSTRUCTION

3.1 Development

In response to the then developing pressure to be able to demonstrate sustainability credentials the UK Concrete Industry agreed upon an initial Sustainable Construction Strategy on 30th July 2008 that had a application period up to 2012. During 2011, following a period of stakeholder engagement the strategy was updated and launched on 20 February 2012 in terms of a revised vision, objectives and commitments. These are:

3.2 Vision

The UK concrete industry will be recognised as a leader in sustainable construction, by taking a dynamic role in delivering a sustainable, zero carbon built environment in a socially, environmentally and economically responsible manner.

3.3 Strategic Objective

1. Commit to our role in achieving a sustainable built environment and contribute to construction industry and government initiatives.
2. Engage with the broader supply chain to inform good practice and continue to explore new ways of improving our sustainable production performance
3. Communicate with clients to provide knowledge of concrete solutions to enable the design and construction of a sustainable built environment

3.4 Commitments

1. Contribute to the delivery of a Zero Carbon built environment
2. Provide Life Cycle Assessment data compliant with codes and standards
3. Develop a Material and Resource Efficiency Programme to inform best practice across the life cycle of concrete in the built environment
4. Develop a Low Carbon Freight Initiative to support improvement in transport performance through the concrete supply chain to the construction site
5. Develop a Water Strategy to support the measurement and reporting of sustainability performance and target setting
6. Target continuous improvement of sustainable production performance and report performance annually

4. PROGRESS

4.1 Concrete solutions

On the specific challenge to ensure that clients are made fully aware of the concrete options to meet the demand for low-energy housing specific research has been commissioned and reported [16]. Figure 1 shows an example of the results where the cumulative CO_2 emissions, embodied and operational, have been modelled for a 60 year period for both lightweight (timber) and medium weight (blockwork walls) simple semi-detached house. Due to predicted increase in summer temperatures resulting from climate change , the lightweight house needs air-conditioning by 2021, whereas for a medium weight home it would not be needed until 2041. A typical concrete and masonry house with a medium level of thermal mass has about 4% more embodied CO_2 than a lightweight house, but this could be offset in as little as 11 years due to energy savings provided by its thermal mass. Guidance, including software has been published[17]. Guidance has also be published on the utilisation of thermal mass in non-residential buildings[18], but this is only example of the continuing work required to demonstrate that concrete is the primary sustainable construction material.

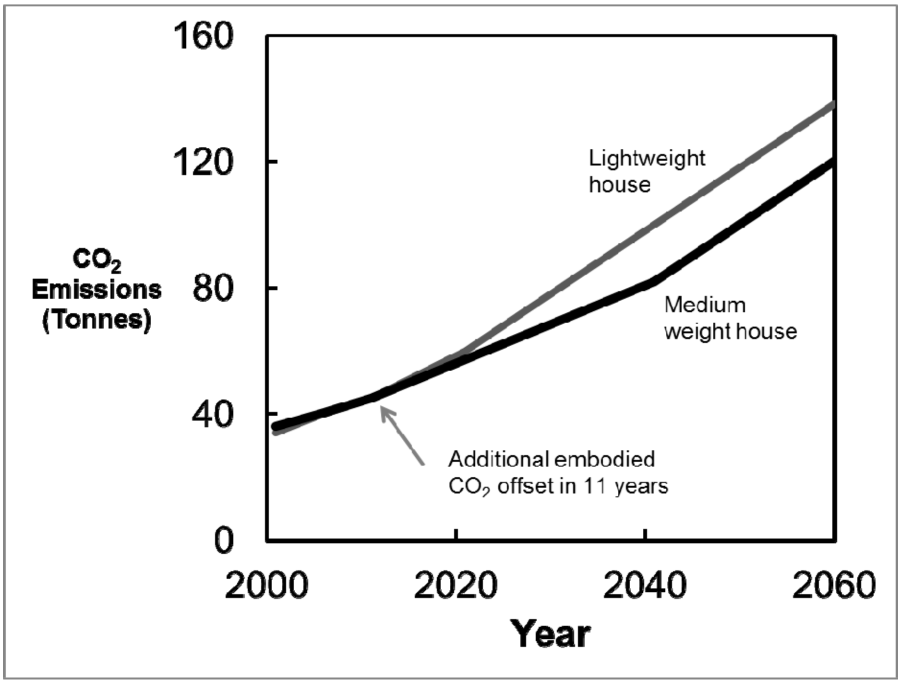

Figure 1 Cumulative CO2 emissions (air-conditioned)

In addition to the thermal performance part of the strategy is to continue to remind clients about the durability, robustness, flood and fire resistance as well as the acoustic performance of concrete solutions.

4.2 Embodied CO_2

The largest proportion of the embodied CO_2 in concrete is attributable to the cement that binds the aggregates together. However, in the UK there are a range of non-CEM I cements available which are usefully used in concrete and carry a lower CO_2 burden. As well as these factory made-composite cements the UK has standardised conformity procedures to facilitate the use of combinations of CEM I with separate additions, such as ground granulated blastfurnace slag (ggbs), fly ash and limestone fines in the concrete mixer such that the combination is equivalent to the EN 197-1 cement of the same nominal proportions. The equivalence is demonstrated by rigorous testing and certification that is considered to give the same degree of customer assurance as that for factory-made composite cements. Because of this rigorous procedure it is only the highest performance additions that can be used in combinations, and depending on the certified cement strength class then the proportions of addition may be restricted below those permitted in EN 197-1. In UK experience the extra cost of the rigorous 'Equivalent Performance of Combinations Concept' is both commercially and environmentally advantageous to the EN 206-1 'k' factor rules for using additions in concrete.

So far the CO_2 emissions for a standardized concrete mix has reduced by 16.3% and is on track to meet the target 17% reduction by 2012.

4.3 Responsible sourcing

Parts of the UK Sustainable Construction Strategy are concerned with the social aspects, where 94% of BRMCA members were accredited to the responsible sourcing standard BES 6001. Although a voluntary requirement there are a significant number of clients who consider evidence of responsibly sourced materials essential.

4.4 Waste

There is very little waste associated with ready-mixed concrete as there is no packaging and the precise volume required can be delivered to site, normally just in time for it to be used. The small amounts of concrete that are returned, and any washout, is normally processed to reclaim the aggregate or left to harden for use as recycled concrete aggregate. Notwithstanding this, BRMCA members have reduced waste by around 60% since 2008.

4.5 Recycled aggregates

With more than 28% of GB aggregates coming from recycled and secondary sources, Great Britain is among the best in the EU at minimising the use of primary materials. Secondary and clean recycled concrete aggregates are safe to use as a constituent of ready-mixed concrete where they are in accordance with the appropriate Standards and industry protocols. In the UK there are limits on masonry, fines, lightweight material, asphalt, lightweight and foreign material as well as soluble sulphate to help ensure the recycled aggregate is safe to use.

4.5 Water

Not long ago in the United kingdom the idea that fresh water is a finite resource did not appear to be credible, particularly in the North and West. However, 2012 has seen the lowest volumes and aquifer levels since 1976 and a drought order has been issued for most of Sooth and Eastern England. Although industrial use of water is not generally covered by environmental assessment systems it is likely that water will be an issue of increasing importance, where this is anticipated in the UK Construction Industry Strategy.

5. CONCLUSIONS

The UK experience is that there is increasing requirements to both demonstrate and achieve improved environmental performance, as well as confirm other important sustainability credentials. In response the UK Concrete Industry has taken the brave step of agreeing to a Sustainable Construction Strategy and a range of very specific objectives and commitments. Although the commitments to help provide support to develop sustainable solutions and improve and report on production performance are demanding, in reality there is no alternative as sustainability is not an issue that will go away.

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