Carbonation from an environmental perspective

Tom De Saulles of MPA–The Concrete Centre looks at why carbonation is surprisingly becoming an important aspect of concrete's environmental performance.

Over the past decade or so, revisions to Part L of the Building Regulations have steadily cut the operational CO_2 emissions from new buildings, largely through greater insulation and airtightness requirements. Sadly, there are practical limits on how much further these Regulations can be enhanced in the future, as the law of diminishing returns applies.

So, in the on-going drive to cut the carbon footprint of buildings, more attention is now being paid to the embodied impacts of the fabric itself. This is also being driven by the changing ratio between the operational and embodied CO_2 of new buildings, which has shifted from around 9:1 to a ratio of about 7:3, meaning that the embodied aspect has become more significant as operational carbon emissions fall. Although the physical amount of embodied CO_2 remains about the same, this shift has nevertheless moved its significance further up the sustainability agenda.

Of all the major suppliers of construction materials, the timber sector is probably the most vocal about embodied impacts, with much attention given to the sequestered CO_2 in timber. To some extent, concrete will of course also absorb CO_2 through carbonation, with the benefit that it remains locked in and is not released when, in the case of timber, it ultimately decomposes or is burnt. As a consequence, the relevance of carbonation is now broadening to include its positive contribution to the environmental performance of concrete.

To get an idea of how much carbon is typically absorbed during the life cycle of concrete, the British Cement Association (now MPA Cement) undertook a recarbonation study(1) in 2007, with the objective of investigating its significance from an embodied CO_2 perspective. The study adapted a methodology for calculating uptake that was developed by the Nordic countries(2). This was applied to the UK cement/concrete market, taking account of the volumes produced for each of the main applications, along with typical mix designs and strengths. A service life of 60 years was assumed, followed by a secondary life of a further 100 years as a recycled material. These periods were agreed with the BRE, which went on to use the study to update the way carbonation is accounted for in its *Green Guide* ratings. Results from the study showed the extent to which the initial embodied CO_2 of cement leaving the factory gate will, on average, be reduced by the end of the 160-year period as a consequence of carbonation. This reduction was found to be approximately 20%, or to put it in terms of concrete, RC 40 made with CEM I will have its initial embodied CO_2 reduced by about 30kg, to a total of around 131kg CO_2/tonne after 160 years.

Study

As you would expect, the study showed that carbonation during the service life period was relatively low for ready-mixed and precast concrete, which were assumed to be relatively high strength. However, it was much more significant during the secondary life stage, when a high proportion of concrete is crushed and recycled. The shift is a consequence of the crushing process, which hugely increases the surface area, greatly increasing CO_2 uptake even when used in groundworks, albeit at a slower rate than when it remains above ground. Using figures from WRAP(3) and Government research into construction waste(4), an average crushing rate of 61% was assumed for UK concrete. However, the reports containing these data were already a few years old at that time and anecdotal evidence suggests that the current rate is likely to be higher. This is significant as it means that the average carbonation rate calculated in 2007 is likely to be an underestimate by today's standards.

The crushing and recycling aspect of the original study has recently been looked at in more detail by MPA–The Concrete Centre to see how much CO_2 is likely to be absorbed specifically during the deconstruction and demolition of a building. This represents a distinct phase in the life cycle of a building as set out in BS EN 15804(5), the Standard that provides the core set of Product Category Rules for the Europe-wide generation of Environmental Product Declarations (EPDs), which will soon start to appear.

A not uncommon life-cycle scenario that could be included in an EPD, is where a building is demolished and the various materials are sorted on-site, remaining there for a number of weeks or months prior to reuse. Although in life-cycle terms this may seem a short period, the exposure of crushed concrete to air for even a few weeks results in a relatively rapid uptake of CO_2. This carbonation, and that which occurs during the life of the building, will influence the carbon figure reported in an EPD, as both are part of the building's life-cycle detailed in the Standard. Uptake during the deconstruction and demolition stage is dependent on a number of factors including time but initial calculations suggest that it will be of the order of 4% or more of the initial embodied CO_2 of the concrete – a not insignificant amount.

Carbonation occurring beyond this point will, under EPD rules, mostly be attributed to the recycled concrete in its secondary life. So, while the overall uptake is likely to exceed 20% of the initial embodied CO_2, this will only go partly towards lowering the embodied impact of the concrete specified for the building, with most of the remainder allocated to any secondary life it may have as a recycled product.

Work in this area will continue alongside the development of Products Category Rules for EPDs, helping ensure that the environmental performance of concrete used in buildings is accurately accounted for when environmental assessments are undertaken in the future. ●

● Footnote:
Some readers may be bemused to read of carbonation being a positive thing, when so much research, specification and workmanship guidance over the years has been expended on reducing it. There is no suggestion whatsoever that there is any motivation now to induce carbonation. Protection of reinforcement from corrosion remains paramount and indeed is the most sustainable thing to achieve. However, carbonation is a reality and should be taken into account when carbon footprinting.

References

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