PLAYING THE LONG GAME

Assessing lifecycle CO_2 is set to become easier with the development of new tools for designers and specifiers, writes Tom De Saulles

For concrete buildings, the broad whole-life carbon dioxide (CO_2) merits can be quite compelling, but at present, the challenge remains one of validating these in a quantifiable way. From 2016, the syllabus for GCSE Chemistry in schools will cover the lifecycle assessment (LCA) of materials and products – a significant step, highlighting how mainstream this technique for assessing environmental performance has become since its origins back in the 1960s. Fifty years on, LCA is the tool being used to produce Environmental Product Declarations (EPDs) for construction materials and products, offering robust environmental information based on a common set of rules.

EPDs offer a useful means for comparing material options, allowing those with favourable attributes, particularly in whole-life terms, to be identified from the outset. This is not the whole story though, as there is also a need to consider how materials measure up in terms of their contribution to overall building performance – that is, their interaction with other aspects of the design. This presents a significantly more challenging task, particularly given the complexity and variety of lifecycle scenarios that could ultimately play out.

The good news is that these issues should become more soluble as new design tools are developed in response to BS EN 15978 for assessing the environmental performance of buildings. Developed by the same European technical committee behind EPDs, this standard came out in 2011 and is likely to become the dominant calculation method used by the construction industry, bringing together all the elements of whole-life assessment into a single methodology. Among other attributes, this will enable any synergies or trade-offs between embodied and operational impacts to be rapidly assessed for a variety of design solutions and lifecycle scenarios.

New guidance

Unsurprisingly, such a holistic approach is not without its headaches, as it must combine the complexities of all the various building design disciplines into a single, interactive assessment tool, which is why the industry is not quite there yet. But there are some encouraging signs, with Sturgis Carbon Profiling for example, aiming to deliver a UK-wide implementation plan for delivering whole-life carbon reductions in accordance with BS EN 15978 by mid-2017.

For concrete buildings, the broad LCA benefits that such tools are likely to highlight will not come as too much of a surprise, as the inherent durability and operational merits are already accepted design doctrine for many. To help quantify these benefits, and highlight other less obvious lifecycle benefits, The Concrete Centre has published a new guide, focusing specifically on the CO_2 performance of concrete buildings and their whole-life footprint.

The guide helps to bridge the current information gap in terms of what we broadly know now and what forthcoming LCA tools will be able to validate more accurately at a project-specific level in the future. The guide sets out the various ways that concrete can directly or indirectly be employed to reduce CO_2 emissions at each stage in a

Photos: Tim Crocker

ABOVE Elizabeth II Court's refurbishment by Bennetts Associates introduced an external courtyard on the site of a former car park (see below right). In keeping with modern needs, 250 parking spaces were cleared, and ample cycle parking has been provided

building's lifecycle, showing the indicative savings that can be achieved.

The opportunities described fall into five areas:

1. Lean design Multitasking with concrete to allow other materials to be designed out or minimised

2. Operational energy Using concrete's thermal mass to reduce energy use

3. Maintenance Using concrete's resilience to minimise the need for maintenance and repairs

4. Reuse Reducing the impact of new-build through the ability to reuse and adapt concrete buildings

5. End-of-life The absorption of CO_2 into concrete by carbonation at end-of-life and following recycling.

The lean approach

"Lean design" in the context of this guide centres on the potential to design out finishes such as suspended ceilings and floor finishes through the use of visual concrete – for example, exposed soffits, polished concrete floors or fair-faced walls. Research undertaken by the Waste and Resources Action Plan (WRAP) shows that avoiding the need for suspended ceilings can save around $10kgCO_2/m^2$, with a higher figure of around $20kgCO_2/m^2$ for avoiding floor finishes. These figures do not include ongoing maintenance and replacement impacts that would also have been avoided.

Alongside these savings is a potential reduction in operational CO_2, which a visual concrete finish can deliver through exposing thermal mass contained in the structure. This helps to regulate the internal temperature, reducing the need for mechanical cooling and associated plant. Over time, a sizable CO_2 saving can result which, in the case of an exposed soffit, may be sufficient to offset the embodied CO_2 in the floor slab several times during the life of the building.

Refurbishment and reuse

Refurbishment, in preference to new-build, is an increasingly pragmatic option and arguably the principal means for optimising whole-life performance. The CO_2 savings that can be realised from extended a building's life are of course largely project-specific, but essentially equate to that of a new concrete frame – that is, the avoided element in a reused building. Based on a range of published studies, the initial embodied CO_2 figure for the superstructure of an office is generally around 200-$250kgCO_2/m^2$ and, as a point of interest, is applicable to both concrete- and steel-frame buildings, both of which have a similar CO_2 footprint. This figure provides an indication of the embodied CO_2 savings that can be achieved. For other building types the figure may vary slightly – for example, hospitals and schools are likely to

▲ Elizabeth II Court

Winchester, Bennetts Associates, 2009

Hampshire County Council's headquarters is a good example of how a client's need for increased space and improved energy efficiency can be fulfilled through reuse – here saving around half the embodied CO_2 and cost associated with new-build. The 1960s concrete-frame structure was retained and adapted to meet modern needs, which included a significant upgrade to the fabric performance, resulting in a reduction in annual emissions from $100kgCO_2/m^2$ to $35kgCO_2/m^2$. Year-round comfort was also improved, helped by passive design measures that centre on the use of exposed soffits and natural ventilation.

THE DEMOLITION AND CRUSHING OF CONCRETE RESULTS IN A SURPRISING AMOUNT OF CO_2 BEING ABSORBED INTO THE NEWLY FORMED CONCRETE AGGREGATE

be about 5% and 10% higher respectively.

A prerequisite for reuse is the ongoing viability of the frame in terms of its layout, slab-to-slab height, floor loads, servicing etc. While less of an issue in high-rise housing, these considerations are especially relevant to commercial projects, particularly where a change of use is planned. It is fortuitous therefore that these are often broadly satisfied in concrete-frame buildings despite little or no consideration being given to future reuse in the original design. A likely explanation for this is that many existing buildings broadly conform to what is termed today as a "long life, loose fit" approach, which combines the use of durable materials with a format that is not tailored too tightly to the building's original function.

Alongside this is the potential to upgrade concrete structures cost-effectively, including the ability to extend and add floors. In terms of their remaining structural life, condition surveys of older concrete-frame buildings often provide a favourable outcome in terms of their ongoing viability and suitability for refurbishment, albeit subject to any minor repairs or localised strengthening that may be required.

End-of-life

Moving finally to the end-of-life stage, it is a little known fact that the demolition and crushing of concrete results in a surprising amount of CO_2 being absorbed into the newly formed concrete aggregate due to carbonation. During the in-use phase of the building, this naturally occurring process is purposefully limited to the surface layer of concrete, preventing corrosion of any embedded steel reinforcement. When concrete is crushed, however, its surface area increases substantially, allowing CO_2 to be absorbed much more rapidly.

Although the deconstruction and demolition process can be comparatively brief, the resulting carbonation is an important consideration when evaluating the whole-life CO_2 performance of concrete buildings. To put it into context, end-of-life carbonation accounts on average for a useful 5% reduction in the cradle-to-gate embodied CO_2 of structural concrete. Looking beyond the building lifecycle to the secondary life of recycled concrete, carbonation continues even when used in groundworks, leading to an ultimate reduction of around one-third of the original cradle-to-gate CO_2 value.

Although concrete's whole-life virtues are quite significant, it is probably going to take the arrival of new, comprehensive LCA building design tools to put these firmly on the map. But it is encouraging that the design conversation has already shifted markedly towards whole-life CO_2 thinking and away from a cradle-to-gate approach. The development of LCA building design tools to BS EN 15978 will help bring all the pieces of the sustainability jigsaw together and should prove effective in cutting through sustainability rhetoric.

For references to the figures provided here, and for further information, see Whole-Life CO_2 – Benefits and Opportunities of Concrete Buildings, published by The Concrete Centre

BELOW The facade of Elizabeth II Court was updated to meet modern needs. The project was praised by the Carbon Trust as a flagship for what can be achieved through intelligent refurbishment rather than demolition and new-build

Photo: Tim Crocker