What is embodied carbon?

The five main areas of greenhouse gas impact from a typical building project are –

- **Management Carbon** (Mc) – the off-site cost of managing the delivery of a project – customer, consultants, contractor, etc
- **Embodied Carbon** in materials (Ec) – the carbon impact of the extraction, production and assembly of the raw materials and components of a project.
- **Construction Carbon** (Cc) – the carbon input required to assemble the building on site
- **Operating Carbon** (Oc) – the cost of operating and maintaining the building through its working life
- **Deconstruction Carbon** (Dc) – the impact of taking apart the building at the end of its life, and recovering materials for reuse or recycling, landfilling or other disposal.

Of the total (the Whole Life Carbon, WLc), embodied carbon (Ec), and operating carbon (Oc) are the two major contributors. At present, the focus is on reducing operating emissions ('zero-carbon buildings'), an area in which the structural engineer can make some contribution, but which is primarily driven by other members of the design team. However, the frame and envelope of the building contain a relatively large proportion of the project's embodied carbon, and it is in this area that the structural engineer can make a significant impact, particularly as reductions in operating emissions become harder to achieve.

But what is 'embodied carbon', and how do you calculate it?

Embodied carbon is quite simply the carbon dioxide emissions[1] generated in producing the materials that are used in the construction process, from the obvious elements such as steel, timber, masonry, cement and aggregates, through to the more complex constructions and systems such as a window unit, or a complete air conditioning unit. These emissions are not only from the sourcing of the raw materials from the earth and their conversion into a usable form, but also from the energy used whenever work is done on them, for example the fabrication of raw steel sections into the individual members of a steel frame.

Transportation

But then there is the issue of transportation – how should you compare a product shipped halfway around the world in a container to a similar item road-hauled from Europe? And what about the waste generated in its manufacture? Is this part of the product's 'carbon footprint', or does it belong to something else? And when you are calculating the carbon impact of the energy used in any process, should you use national averages, or the actual energy impact at the plant? For example, a manufacturing company may have signed up to a green energy tariff or use energy from a renewable source – should products from this plant have a lower carbon footprint than those from another plant that does not use 'green energy'? There are many similar questions.

Methodology

Much of the methodology of carbon footprinting is drawn from the discipline of Life Cycle Analysis (LCA), where these issues are referred to as 'boundaries'. It is essential to know and understand the boundaries that have been assumed for any declared carbon footprint as this tells you what is included – and what has been left out. So can you compare the carbon footprint calculated to one set of boundaries for one product, to the footprint of another calculated to a different set of boundaries? Yes you can, but only by working with your supply chain to understand the boundaries used.

But how much better would it be if everyone worked to a common standard?

And therein lies the current problem – there is no single standard or methodology in place today that is broadly recognised as being the 'right way' to calculate embodied carbon, although many trade and industry bodies are working on potential solutions. One of these is a new industry specification (PAS 2050) which is currently being developed by BSI, which builds upon the original methodology proposed by the Carbon Trust. When this (or another standard) becomes broadly accepted within the industry and a set of industry-average figures for construction materials is derived using it, the way is then open for structural engineers to make informed decisions on the relative merits of alternative solutions, not only on the basis of structural performance, but also on carbon impact, and to actively consider this as part of the design process.

Detailed specification

The next stage would be to take this way of thinking into detailed specification. If everyone calculates embodied carbon to the same standard, then as you move away from the generic analysis at the start of a project into detail design and specification as the project progresses, there is the opportunity to confidently specify a particular manufacturer's products with a lower declared carbon footprint, knowing that you will be further lowering the overall carbon impact of the design.

Role for structural engineers

By recognising and reducing the carbon emissions to the atmosphere associated with the initial construction of the project, and hopefully mirroring the efforts that are being made by other members of the design team to reduce the operational carbon emissions during the life of the building, structural engineers can play an important role in the achievement of genuinely low carbon construction over the whole life of the building – in construction as well as in use.

1. Carbon dioxide emissions are frequently referred to as 'carbon dioxide equivalent' or 'CO_2e', as other gases as well as carbon dioxide cause greenhouse effects. For example, methane is 23 times more potent in terms of greenhouse effect, so 1t of methane is considered to be the equivalent of 23t of carbon dioxide. To avoid having to refer to each of the gases individually, the effect of the various gases given off during any process is normalised to their 'carbon dioxide equivalent' (CO_2e), and just the single unit used for any calculations.

Further reading

Smith, B. P. 'Whole-life carbon footprinting' *The Structural Engineer* **86**/6, 18 March 2008 p.15/16.

Further information

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