The Carbon Index

This article discusses on the importance and fundamental concepts of the Carbon and the Carbon Index, and how it will eventually affect the Construction Industry.

What is Carbon?

Carbon, in the form of carbon dioxide (CO_2), is recognized as one of the major greenhouse gases released to the atmosphere as a result of human activities, and largely due to the burning of fossil fuels, land degradation like mining and deforestation. CO2e is an abbreviation of 'carbon dioxide equivalent' and is the internationally recognized measure of greenhouse emissions. There are 6 types of greenhouse gases controlled by the Kyoto protocol. These include: carbon dioxide (CO2), nitrous Oxide (N20), methane (CH4) and a range of synthetic (industrial) gases including perfluorocarbons (PFC), hydrofluorocarbons (HFC) and sulphur hexafluoride (SF6). Each of these gases has a different capacity to heat the atmosphere - global warming potential (GWP). CO2 is not a potent greenhouse gas (GWP of 1) compared to the others. However, because CO2 is produced in such huge quantities, its effect dwarfs all the other greenhouse gasses combined.

To illustrate, when an organization calculates its greenhouse emissions these are reported as though they were equivalent to a given volume of CO2. This is the CO2e. For example, greenhouse emissions from a landfill of 100 tons of methane are recorded as 2,100 tons CO2e. Using CO2e as a measure of greenhouse emissions allows for comparing the greenhouse impact of a variety of greenhouse emissions sources.

Carbon Index

Greenhouse gases (GHGs) are synonymous with global warming. To mitigate the effects of global warming, there is a need to reduce energy consumption or to have energy efficient buildings and one method used to measure energy rating is the universal Standard Assessment Procedure (SAP). The ratings are from 1 (poor) to 100 (good).

A relatively new method of energy rating that measures the amount of carbon dioxide emitted by a building's energy system is carbon indexing. A carbon index of 8 is roughly equivalent to SAP's 100.

Carbon Footprint

The first step in developing a carbon management strategy for buildings will be to accurately measure the current level of carbon emissions – that will be your carbon footprint. Carbon footprint is essential for building owners to set benchmarks to measure carbon performance and to compare amongst other properties. These measurements would also enable building owners to maximize energy efficiencies and returns through identification of energy inefficient areas.

The carbon footprint for buildings includes embodied carbon and operational carbon.

The embodied carbon of a building are from the CO2 produced during the manufacture of materials, their transport and assembly on site, maintenance and replacement, disassembly and decomposition. Operational carbon is carbon emissions due to the operations of the building. A typical carbon footprint of a building would ideally include the following:

- material development and preparation;
- construction process (including transport);
- disposal or ongoing occupational emissions from tenant occupiers; and
- Refurbishment and redevelopment.

Carbon Index and the Quantity Surveyor

Embodied carbon accounts for only 13-18% of the total carbon footprint of any construction project (UNEP, 2007) which explains the rationale of initiatives focusing on increasing energy efficiencies to curb operational carbon emissions. However, as buildings become more energy efficient, the more important the embodied carbon becomes as it would then make up a much greater percentage of a low-energy building's total lifetime carbon footprint.

With the current emphasis on energy efficiency, there is an increasing need for building owners and building designers to be more concerned in the real carbon footprint of their buildings to take careful account of embodied energy and associated CO2 emissions. In response, quantity surveyors can merge their cost plan tools with a suitable carbon rating that can identify the building elements which carry the highest carbon costs and in turn value engineer to mitigate the risk of incurring a high carbon footprint so as to achieve energy-efficient and carbon-efficient building.

The difficulty of calculating embodied carbon emissions is that many variables affect the carbon intensity of products, including manufacture, transport, primary energy sources and the extent of waste or recycling. However, as some processes and products are more carbon-intensive than others – cement, aluminum and glass being good examples – it is not necessary to calculate the absolute total carbon footprint of a project, as many components will have a negligible impact and offer limited opportunities for mitigation. An approach that focuses on the most carbon-intense and extensively used components can be adopted, applying the principles of significant item cost estimating to the assessment of carbon, and adding an allowance for the remainder (Wright & Rowlinson, 2007).

How to Calculate Embodied Carbon

With the methodology established by our Davis Langdon & Seah International, M/s Davis Langdon office in London, we will illustrate 2 case examples on how to calculate embodied carbon.

Case study A illustrates how a composite embodied carbon rate is built up for concrete ground slab options, based on ordinary Portland cement (OPC) and 30% pulverized fuel ash (PFA) mix. Calculations are based on a single square meter of slab.

- The original embodied carbon data is based on mass, so conversion to the built quantity is required for all components
- The results are expressed in units that are used in the original cost plan
- There are two or three items which have a significant impact on the total, in this case cement, reinforcement and disposal of excavated material. Other items account for less than 20% of the total. While the calculation must be detailed for carbon-intense items, those with low impact can be dealt with as a percentage adjustment, once the relationship is understood
- Changes to specification can have a dramatic effect on a building's footprint.

Use of PFA in this example reduces the embodied carbon by nearly 19% compared with a standard concrete mix. There are many other opportunities to mitigate embodied carbon impacts

- Mitigation may be constrained by availability of substitutes, or the programme and costs. However, the embodied carbon approach helps ensure the issues are considered alongside a project's other success factors.

Material assessment: ground slab		
Total embodied carbon emissions/m2 of slab area103.2		
Concrete mix based on 30% PFA substitution of OPC		
	Kg embodied carbon/unit	Kg embodied carbon/m2 gifa
Excavation (m3)/ PFA mix	11.1	6.66
Disposal (m3)	16.7	10.02
Blinding, 75mm thick (m3)	9	0.72
Concrete, 200 thick, OPC cement (m3)	309.1	61.82
Reinforcement, A252 mesh (kg)	0.44	1.72
Movement joints (m)	8.7	0.44
Damp proof membrane (m2)	0.7	0.7
Insulation board (m2)	1.7	1.7
Total embodied carbon emissions/m2 of slab area		83.8
Exclusions: demolition and disposal of slab construction at end of life Gifa: Gross Internal Floor Area		

Case study B extends the assessment to a whole building, in this case a distribution centre. It is an abbreviated BCIS elemental summary and has been derived from the application of cost plan quantities to Davis Langdon's embodied carbon rates database.

The results of the assessment illustrate the impact of a few components on a building's carbon footprint. The ground slab is the most important element, accounting for 42% of emissions, but in cost terms it equates to only 17% of total cost.

The, frame, roof and external walls, account for the most value in shell construction – about 32% of both the carbon footprint and capital cost. While this shows carbon often "follows mass", the quantity of external envelope relative to floor area means walls and roofs also present an opportunity to reduce the carbon footprint.

The assessment also encourages proportionality. In this case, the results show mitigation efforts focused on finishes and services (equating to 10% of embodied carbon and capital cost) yield less cost-effective outcomes. For services, focusing on reducing in-use energy consumption would probably yield best outcomes.

Building assessment: distribution centre				
	£/m2 gifa	%	Kg embodied carbon/m2 gifa	%
Substructure	59	17.4	146.5	42.3
Frame, upper floors and stairs	60.7	17.9	68.4	19.7
Roof	48.5	14.3	41.6	12
External walls, windows and doors	14.7	4.3	13.3	3.8
Internal walls and doors	0.8	0.2	2.3	0.7
Internal finishes	4.4	1.3	5.6	1.6
Building services installation, including dock levellers	31.8	9.4	30.2	8.7
External works and services	81.4	24	38.6	11.1
Preliminaries	37.5	11.1		
Total construction cost/m2 gifa	338.8	100		
Total embodied carbon emissions/m2			346.5	100
Exclusions: site preparation, site abnormals, distribution centre and administration area fit-out, operating equipment, professional fees				

With the calculations of embodied carbon coupled with current operational carbon measures, it is possible to provide a holistic view of the impact of Clients' developments.

As the data bank for carbon index improves, we will be able to band buildings by their embodied carbon rating and clients will gain a greater appreciation of their buildings and their project teams' roles in addressing carbon impact through:-

- Intelligent specification, based on impact as well as ease of implementation
- Creating demand for products with low-carbon processes
- Encouraging demand to create market transformations in carbon-intensive sectors of the supply chain
- Fostering an appreciation of the impact of strategies such as renewable energy technologies
- Encouraging the use of recycled and recyclable products
- Designing for deconstruction

Conclusion

There has been an overwhelming plethora of evidence on the impacts of climate change to give clear and strong signals to economists and policy-makers in shaping a response. One of the strongest signals sent out to date is the legislation of Green Mark Certification in April 2008 which was hitherto a voluntary scheme since its inception in 2005.

Furthermore, there has also been a growing emphasis on curbing of carbon emissions in the construction industry which is best epitomized by two recent events. Firstly, the launch of the Clean Development Mechanism (CDM) Documentation Grant by the National Environment Agency (NEA) whereby S$500,000.00 worth of funding will be provided to encourage companies to develop CDM projects in Singapore which includes engaging a carbon consultant to develop a new methodology and Project Design Document (PDD). The other milestone event is the possible listing of a carbon trading fund worth more than 250 million euros (S$532.4 million) which is among the first of such funds to debut in Singapore.

In a bid to keep abreast of the latest development in the industry, Davis Langdon & Seah Singapore in conjunction with National University of Singapore and the Building Construction Authority of Singapore are currently in a joint research to develop a comprehensive carbon library resource (Carbon Index) on construction materials and systems. The Carbon Index would enable a standardized measure of carbon ratings and facilitate in embodied carbon measurements in relation to the cost reporting format in CP80. As highlighted in the above report, the seamless integration of embodied carbon components to the existing cost plans template would provide Building owners with a more comprehensive outlook over the properties.

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