Challenging the current approach to end of life of buildings using a life cycle assessment (LCA) approach

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Abstract

Life cycle thinking has been applied in the construction industry for more than 20 years for the environmental evaluation of construction products and processes. Life cycle assessment (LCA) is the tool that enables the quantification of environmental impacts using parameters appropriate to the various potential environmental impact categories. Standards have developed alongside to support this process, under the ISO 14000 series, ISO 21930 and 21931 for construction products, and lately European standards aimed at harmonising approaches to LCA in construction in Europe, specifically EN 15804 for product level assessments, and EN 15978 for building level assessments. EN 15978 provides a modular approach through which the environmental impacts are reported for different life cycle stages across the processes for the provision of the products and services used in the construction (A1 to A3), the delivery of the products and services to site and the actual construction process (A4 and A5), the use of the building including maintenance, repair and replacement, and energy and water use (B1 to B7), and the demolition/deconstruction and end-of-life management processes for the building (C1 to C4). There is also a further life cycle stage (D) which is aimed at evaluating the benefits or burdens resulting from any potential future reuse of components of the building which would otherwise have been disposed of as wastes from either the construction, use, or end-of-life of the building. On the whole this represents a linear approach to assessing buildings, to which a paradigm shift will be needed to apply the principles and benefits posed by circular economy thinking to the construction sector. Part of the H2020 funded project BAMB (Building As Materials Bank) will be to develop a methodology to assess the potential circularity of a building and, in particular, will investigate the potential role of LCA in circular economy.

Keywords: LCA, circular economy, Module D, end of life.

Introduction

The way we, as a society, “take-make-dispose”, relies on the availability of cheap resources. However, as the population and economy grow, the demand on resource availability and landfill disposal increases. There is a need to decouple economic growth and resource use. The concept of the circular economy as a way of decoupling growth from resource constraints is therefore becoming an attractive way forward. The construction industry accounts for 60% of UK materials consumption and one third of all waste arisings in the UK and as such much focus has been put on this sector to reduce its environmental impact. Whole building level assessment schemes have supported the development of more sustainable buildings, considering issues such as operational and embodied impact (through a life cycle assessment (LCA) approach) and waste reduction. LCA is currently considered the standard approach by the industry to calculate the embodied impact of buildings.

BAMB methodology development

Part of the H2020 funded project BAMB (Building As Materials Bank) is to create and test a decision support methodology, integrating input on materials, reversible design, reuse potential and transformation potential of buildings, systems and components. Having such information readily available, at key stages of design, product selection & procurement, operation, maintenance, refurbishment and deconstruction of a building's life cycle, will enable better decisions to be made in ensuring the value of buildings, and their constituent parts are enhanced, rather than deteriorated.
Part of the methodology development involved reviewing the current approach to calculating the economic, environmental and social aspect of buildings and to understand how it can be applied or adapted to represent a circular economy concept. Thus we have evaluated the methodologies and approaches that are currently being used in the construction industry, including information data/databases, studies, tools and methodologies that already exist or in development. The focus has mainly been on use in Europe and the construction sector (building and infrastructure, new and refurbishment projects), but other sectors were also included if appropriate.

The review covered the following categories:

- Materials efficiency
- Design for deconstruction
- LCA and Life Cycle Costing (LCC)
- Procurement and design in buildings
- In-use and asset management

Findings

This section will focus on the findings related to the LCA/LCC categories only. Both LCA and LCC have been used extensively in the construction industry and are well established tools to measure the impact of buildings.
A number of standards have been developed over the years to support the application of LCA to the construction industry at product and building levels, under the ISO 14000 series, ISO 21930 and 21931 for construction products. More recently, European standards (through the CEN TC 350 committee work) have been developed to support a harmonized approach to sustainability in construction in Europe. Those standards apply not only to environmental, but also to economic and social evaluations. EN 15804 supports and LCA approach for product level assessments, and EN 15978 (LCA), EN 16309 (social) and EN 16627 (economic) for building level assessments. EN 15978 provides a modular approach through which the environmental impacts are reported for different life cycle stages across the processes for the provision of the products and services used in the construction (A1 to A3), the delivery of the products and services to site and the actual construction process (A4 and A5), the use of the building including maintenance, repair and replacement, and energy and water use (B1 to B7), and the demolition/deconstruction and end-of-life management processes for the building (C1 to C4). There is also a further life cycle stage (D) which is aimed at evaluating the benefits or burdens resulting from any potential future reuse of components of the building which would otherwise have been disposed of as wastes from either the construction, use, or end-of-life of the building. Another initiative that is being pushed by the European Commission is the development of Product Environmental Footprint (PEF). A PEF is multi-criteria measure of the environmental

performance of a good or service throughout its life cycle. This approach is less established in the construction industry, but nonetheless worth considering for BAMB.

In the last five years, tools have been developed to enable non-LCA experts to carry out the complex process of calculating the embodied environmental impacts of a whole building. Some of these tools are already well established in the market place across Europe. It is indeed important to understand the environmental impact of a product throughout its whole life, including its use in a building, rather than to compare two products on a per tonne basis, eg: 1 tonne of steel with 1 tonne of concrete. The carbon footprint of 1 tonne of steel is more than that of 1 tonne of concrete. However, the mass of steel used for 1 m2 of wall may be less than the mass of concrete required to build the same wall. The transport to site of steel is potentially higher than the transport to site of concrete. They both have the same service life and they can both be recycled – steel may even be reused. Based on all these assumptions, it is hard to make a simple decision on which solution is best. Using a whole building life cycle tool is therefore essential.

A few of these tools are able to import Building Information Models (BIM) models (such as One Click LCA or the IMPACT compliant IES-ve plug-in) and have furthermore allowed integration of LCA calculations in existing software used for other applications, such as thermal modelling. From an environmental and financial perspective, it is important to take into a full life cycle perspective (cradle to grave and beyond), in order to evaluate potential benefits and impacts/costs related to circular and reversible building solutions – compared to the traditional way of building.

Life-cycle cost (LCC) analysis is a method of determining the entire cost of a structure, product, or component over its expected useful life. The cost of operating, maintaining, and using the item is added to the purchase price. The longevity of built assets makes LCC an important tool in balancing costs over a long period. A classic example of where this is often used is the understanding of additional costs in design and build to reduce energy requirements versus the cost savings of reduced energy consumption over the design life of a building.

Financial cost calculations within the building practice are usually done using own calculation spread sheets, based on real costs retrieved from tenders. In general no full LCC is performed. Architectural and engineering firms concentrate their efforts on the initial investment costs related to the design and construction of the building. Facility managers focus on energy and water consumption, maintenance and replacement costs. Concepts such as Return of Investment (or Rate of Return) and Total Cost of Ownership (TCO) are more and more integrated within the design and operation phases. These financial approaches rarely take into account (periodic) replacement costs and cost related to the end-of-use of the building. A full LCC (cradle to grave and beyond) is often limited to academic and policy support studies, and within some certification schemes, such as BREEAM, DGNB and HQE.

Assessment of social performances of buildings are not yet performed very often, although the introduction of EN 16309 starts to support the understanding of what, when or who is impacted by social aspects. Social aspects include: noise and dust created during construction stages, health and safety, security and comfort issues during the construction and use stages of the buildings or involvement of the local community.

According to the UK BIM Task Group, 2013:" BIM is essentially value creating collaboration through the entire life-cycle of an asset, underpinned by the creation, collation and exchange of shared 3D models and intelligent, structured data attached to them." In 2016 the UK government mandated that all government construction projects will be using BIM level 2 regardless of project size. Level 2 is a managed 3D environment held within a separate discipline of "BIM" tools with attached data.

Summary

Tools, methods and standards already exist to evaluate the environmental or financial costs of buildings. Some tools even integrate both elements of LCA and LCC. Outputs of these methods and standards could be used to inform the BAMB methodology. An important outcome of a comparative analysis is that the commonly used standard for LCA and LCC are compatible to each other. However, some methodological aspects related to circular and reversible building solutions are lacking within these standards. For example, there is no guidance related to take into account different possible use scenarios related to replacement, maintenance and transformation. Furthermore, the value of materials and building components are usually depreciated according to their expected service life, without taking into account their real value, in case they are reused and/or remanufactured. On the whole, EN15978 represents a linear approach to assessing buildings, to which a paradigm shift will be needed to apply the principles and benefits posed by circular economy thinking to the construction sector. The BAMB methodology will be building on the approach taken by the industry by including additional indicators, stages, and assumptions. Data should be attributed using an element method. Within Europe the (regionally adapted) SfB method is often used, but alternatives such as the OmniClass, can be considered as well. Using harmonised element codes will facilitate the exchange of environmental and financial cost data. It should be investigated in a further stage of the element method approach can also be used within a BIM environment.

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