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UK apartment construction impact on carbon life cycle calculations

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Abstract

There is no fixed method to analyse the global warming (carbon) impact of a building envelope over its life time, however guidance is given in BS EN 15978 [1].The paper assesses the Life Cycle stages and components in 3 archetypal construction typologies for an apartment building assessed with the BRE Green Guide [2] as a comparator. There is a difference of a factor of 4 between construction types and the position of units within an apartment block. Replacement and recycling factors significantly affect the end results with steel being highly recyclable, concrete advantageous in longevity and timber sequestering carbon at early stages. Timber does have an increased number of replacements during the life span and significant impacts at end of life stages. The BRE quantification does not take into account foundations leading to a climate change impact 3 times lower than a bottom up analysis for a steel building.

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1. Introduction

Architects should design buildings with their life span as a primary consideration. This is not addressed by current UK regulations which only consider a single year of energy use based on historic weather data. As future climate threatens the resilience of the built environment, it is important that a building's Life Cycle (LC) and Green House Gas (GHG) assessments account for climate change. As a building contains hundreds of products within its

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assembly, it is impractical for a designer to conduct an analysis using the BS:EN 15978 [1] modular framework (shown in Fig 1) at the early stages of a design process. Additional problems include the lack of a standardised methodology in quantifying the impact of dwellings within apartment blocks such as the measurement of shared features.

Product stage			Construction		Use stage							End of life			
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
raw material suppy	Transport	Manufacturing	Transport	Construction Installation Process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy	Operational Water	Deconstruction Demolition	Transport	Waste processing	Disposal

Fig. 1. Stages within BS:EN 15978 [1] by author

Building construction materials need to be assessed across a range of LC stages otherwise incorrect assumptions on design decisions are made, especially where a material is to be replaced several times over the building's life. Within this study archetypal buildings are used for comparison of the GHG impact within an apartment block. In considering the LC operational carbon it is important to determine the change in heating and overheating likely to occur due to climate change. Overheating is assessed using the CIBSE TM52 [3] methodology for naturally ventilated buildings as detailed in a previous study [4]. The assessment uses future weather files from Eames et al [5] within a dynamic model to account for different constructions. The study demonstrated the likely date for active cooling to be adopted and determines the subsequent GHG impact on construction types.

This study aims to assess typical apartment buildings using current LC protocols as given by Building Research Establishment (BRE) [2] against a bottom up methodology. The bottom up study uses a comprehensive set of LC stages, where practical, to determine their importance in a GHG calculation of a building. In determining the GHG of differing constructions the effect on other building components and the main features that influence the LC solution for a given life span are identified.

2. Background

The BRE provides voluntary building standards in the UK, part of which contain a LC methodology for a 60 year period. The GHG of constructions is quantified in publications [2] with longer life spans used in PAS 2050:2011 [6] at 100 years and specifications for long life buildings can be 125 years. The apartment life span primarily impacts the operational carbon and replacement factors of materials within a building.

Previous studies have quantified the Embodied Carbon of foundations [7] but do not deal with the superstructure or other systems for the whole building; a holistic picture is required so that design dependencies of different building elements can be understood. Pad, strip and pile foundation typologies are quantified, as part of the building study, dependant on the construction weight of the apartment building considered. The assessment assumes good ground conditions rather than site specifics where surveys and investigations influence the final structural solution.

Environmental Product Declarations (EPD) [8] are used as the GHG dataset for construction materials directly from manufacturers. As timber EPDs account for sequestration [9], it is investigated compared to heavyweight materials [10]. Thermal mass has been shown to delay the installation of active cooling in a future climate thus avoiding operational GHG compared to a lightweight construction. The practicality of the inclusion of all the LC stages in the study are discussed in the methodology.

Three and 6 storey apartment buildings are evaluated with a core serving two apartments per floor, a typical arrangement for many multi occupancy buildings shown in Figure 2. In the case of the 6 storey solution a lift is added to show the influence on the LC calculations. Solutions comply with UK building regulations although the 6 storey timber building assessed would not comply due to a lack of structural redundancy required for disproportionate collapse regulations.