Preview of:

# Life cycle carbon analysis of a six-storey residential building

This preview is authored by The Concrete Centre. It draws on technical analysis completed by Max Fordham, on behalf of The Concrete Centre. The initial designs that formed the basis of the analysis were developed by Adam Khan (Architects), Price and Myers (Structural Engineers) and Max Fordham (Environmental and Services Engineers).

## Executive summary

A life cycle assessment (LCA) of a typical 2500m$^2$, six-storey apartment block building containing 22 flats was carried out using the OneClick LCA tool. Two sets of designs were developed for functionally equivalent concrete and CLT versions of the building. Both have essentially the same size, shape, room layouts and glazing dimensions. The designs also have equivalent heat loss characteristics, solar shading, heating and ventilation systems. The concrete building maximises thermal mass with the use of exposed concrete soffits and high-density blockwork walls.

The modelling covered a 60-year building life cycle, assumed to be 2020 to 2080, and included operational energy, passive cooling, peak heating and cooling loads and embodied carbon emissions. The buildings were assumed to be demolished at end-of-life.

It was found that the whole life carbon (A1- C4, excluding B7 water) of the concrete apartment building was around 6% more than the CLT building over a 60-year lifespan. The embodied carbon (A1 - C4, excluding B6 energy and B7 water) of both buildings was around 500 kg$CO_2$e/m$^2$, which meets the RIBA 2025 and 2030 Climate Challenge targets. The study went on to identify several potential enhancements within the constraints of a relatively fixed design, which were shown to reduce the embodied carbon of the concrete building to around 430 kg$CO_2$e/m$^2$. Broader opportunities for carbon savings identified by the study will inform follow-on work by The Concrete Centre.

As part of the study, overheating performance and peak loads were assessed. It was found that passive performance of the concrete building was significantly better, with a lower occurrence of overheating, enabling the need for active cooling to be avoided for the period 2020-40. The CLT building required an active cooling system from the outset.

Operational energy consumption was similar for both buildings at around 43 kWh/m$^2$/y. When energy generated by the PV array included in the building design is subtracted from this figure, it meets the RIBA 2030 Climate Challenge energy target of 35 kWh/m$^2$/y for residential buildings.

The concrete building's predicted peak space heating load was 25% lower on average. This is beneficial from a plant sizing, cost and embodied carbon point of view. More valuable, however, was the resulting difference in peak electrical demand: Limiting peak electrical demand, particularly in winter, is a vital part of a net zero carbon future as it helps facilitate decarbonisation of the national grid.

## Headline LCA results

- Operational energy consumption over the full life cycle was similar for both buildings.
- The concrete building has an average peak space heating load that is 25% lower.
- The passive cooling performance of the concrete building was significantly better.
- The CLT building required active cooling from the outset, whilst the concrete building can be passively cooled until 2040.
- The embodied carbon of both buildings was around 500 kg$CO_2$e/m$^2$
- The whole life carbon of the concrete building was broadly similar, with the modelled scenario around 6% higher.
- The RIBA 2025 and 2030 Climate Challenge energy and carbon targets for residential buildings were meet by both building designs.

## Headline LCA lessons

- The availability of data for an LCA is lacking in some areas, especially MEP services.
- There is a wider range of embodied carbon rates for CLT compared to concrete (a range factor of 6 compared to 1.1), which could skew results.
- The predicted whole life carbon performance is strongly influenced by the assumed future grid carbon intensity of electricity. Whilst there is some uncertainty about the best value to adopt, using a standardised grid carbon factor across all LCAs would help make results more comparable.
- LCA is currently limited to a building-level assessment but, going forward, the use of smart energy systems and load shifting means it will also need to be assessed at national/grid-level to get a true indication of carbon performance.

## Introduction

To acquire an overall understanding of a built project's total carbon impact, it is necessary to assess both the anticipated operational and embodied emissions over the life of the asset. Considering the combined operational and embodied carbon emissions over a project's expected life cycle constitutes a whole life approach. Its use can help identify the best combined opportunities for reducing lifetime emissions. It can also bring longer-term benefits to the forefront of the design process, ensuring a development is evaluated in the round.

Whole life carbon assessment is attracting broad support from construction sector organisations including the UKGBC with its Net Zero Whole Life Carbon Roadmap, and the RIBA with its Climate Challenge programme. Whole life carbon assessment has also become a planning requirement for large-scale construction in Greater London and is now a government requirement for all new public works projects.

Producing a practical whole life carbon assessment will typically involve the use of a Life Cycle Assessment (LCA) tool that follows the LCA methodology set out by the RICS and/or BS EN 15978. To learn more about this and the process of completing a LCA of a concrete building, The Concrete Centre commissioned a study of a new, hypothetical apartment block in London, designed to meet the Future Homes Standard. An apartment block was chosen in preference to an office or other commercial building as many of the whole life qualities of using concrete in these applications are already more widely understood. For context and LCA comparison purposes, the apartment building was also designed using cross-laminated timber (CLT).

Whilst undertaking the study, a number of useful observations were made and lessons learned. These relate not only to the use of concrete and other materials/systems, but also to the general challenges of completing an LCA. One such observation was the wide range of GWP values included in Environmental Product Declarations for CLT. This led to the use of high, low and medium embodied carbon scenarios to account for the range of data available for the CLT and other materials used (see Figure 1).

Knowledge gained from the study has highlighted areas of design that could potentially be developed further to reduce carbon. A next step for The Concrete Centre will be to look more closely at these to see how they can be progressed. A number of more straightforward design enhancements applicable to the relatively fixed design used in this study were also identified and formed an additional scenario called 'Concrete low2' (see Figure 1).

It should be noted that this LCA focused specifically on the apartment building specified for the study and the results do not necessarily translate to other building types, although the general lessons learnt about completing an LCA are transferable.

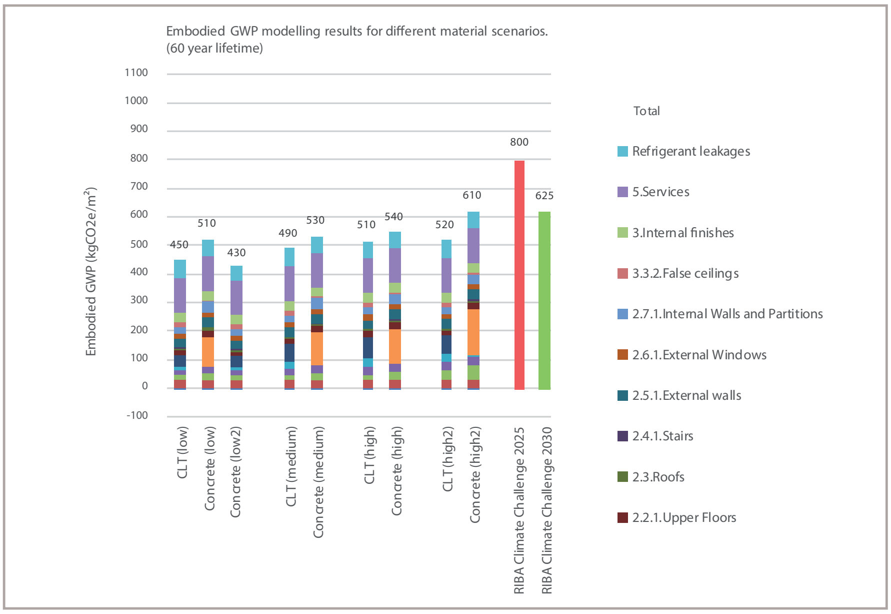


Figure 1: Embodied carbon results for low, medium and high scenarios (A1 - C4 excluding B6 energy and B7 water).

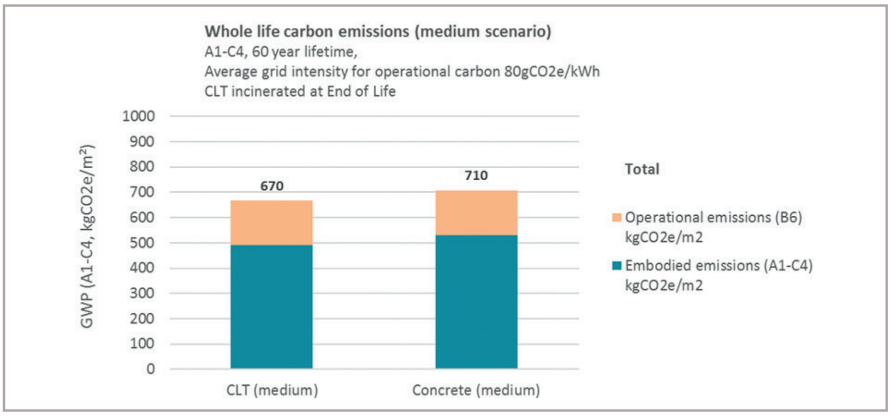


Figure 2: Whole life carbon (A1- C4, excluding B7 water).

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