Carbon-reducing construction methods in infrastructure: a mixed-methods study on life cycle assessment and its implementation

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The construction industry faces significant challenges to meeting net zero targets set by national and international legislation. The Climate Change Act 2008 and its Sixth Carbon Budget commits the UK to reducing carbon emissions by 77% on its 1990 levels by 2037, ahead of achieving a 100% reduction of these emissions by 2050. With the built environment contributing to 39% of global carbon emissions (World Green Building Council, 2023), the construction of new infrastructure can greatly influence this reduction. It is difficult to track precisely what progress the sector has made on these targets to date and how it can achieve net zero.

There is an ambition that carbon calculating tools such as Life Cycle Assessment can play a leading role in project decision-making. These tools provide additional information to traditional project management techniques to allow for the successful delivery of 'sustainable construction projects.'

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This research aims to guide the infrastructure sector on identifying and implementing carbon-reducing methods during the construction phase. The first objective of this research is to understand the state of practice concerning carbon during the construction phase of infrastructure assets. This objective will investigate what carbon calculation methods are preferred within the industry, if relevant data is accessible and, if such methods support construction technologies prevalent within the industry today. The second research objective is to understand the carbon impacts of construction choices regarding a specific infrastructure case. A comparative LCA will establish if decisions made on design choices led to a lower carbon impact of an as-built structure. The final research objective is to understand whether project management and decision-making approaches can support further reducing carbon impact.

Quantitative and qualitative are considered for this research which can provide a more in-depth view of current industry practice and consider what mechanisms it can implement to achieve net zero. The research design is thus mixed-method and uses a sequential explanatory approach. In this approach, the quantitative data is first collected and analysed, which then informs the next phase of data collection and analysis of the qualitative research. This research benefits from this approach because the researcher can form a detailed view of current industry performance through the first phase. This provides good preparation to enable a much richer discussion when examining the lived-in experience of industry professions in the qualitative research phase.

A survey was distributed using convenience and respondent-driven sampling. The results identified the status of carbon management processes on projects and measured the respondent's confidence levels in their implementation. Respondents were invited to give suggestions for improving carbon management processes, which were analysed through a short thematic analysis.

A case study was selected for Life Cycle Inventory (LCI) analysis to examine the carbon impacts of construction-based decisions. Three different construction solutions were analysed for carbon equivalent comparison. The analysis considered both permanent and temporary works activities. Allocation and Module D were investigated for multi-use temporary works items of scaffold, falsework, and formwork.

Finally, the quantitative data informed the questions in semi-structured interviews with senior leaders from contracting, design, and client organisations. A thematic review was carried out, which generates insight into how a new carbon approach' to working can be achieved for the sector to meet net zero targets.

The research concludes with recommendations for both industry and academia. LCI analysis remains open to interpretation. Boundary selection for the processes of allocation and inputs to Module D does not have a robust, consistent approach for practitioners to work to. A more simplified method of carbon equivalent calculation is recommended to aid sign-posting at crucial decision-making stages.

The qualitative study reveals that many professionals are already highly engaged with the carbon agenda. However, there appears to be a clear knowledge gap in how organisations can collaborate to achieve carbon reduction on projects. Understanding the whole life carbon of design and construction solutions and financial implications and how these can be incorporated into contracts appears relatively untested in the industry.

Limitations of this research include the sample sizes for both the survey and interview, which are unlikely to reflect a general population. This also applies to the case study where carbon data was extracted from only one infrastructure project.