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CONSTRUCTION ENGINEERING MASTERS DISSERTATION ABSTRACT

Structural Frame Lifecycle Assessment: Bramley Moore Dock Stadium

Structural frames are designed to suit an architectural vision, geographic location, and end user requirements; each frame must be carefully selected, designed, and constructed. In these conditions, measurement of embodied carbon is a challenge. Steel, concrete and timber comparisons often produce contradictory results, and a definitive decision cannot be made on which material has the lowest carbon emissions.

This paper has found four buildings similar in complexion, location, and purpose, which are designed with alternative structural materials. The literature review has found this to be unique. It uses these buildings to calculate which has the lowest carbon emissions. The assessment uses a RIBA Stage 4 design for the Bramley Moore Dock Stadium in the Northwest of England. The structure consists of two stands designed with reinforced concrete as the primary structural material and two stands using steel. The design has been driven by construction logistics. The four quadrants are analysed for embodied carbon and then compared. This comparison is used to define which material design has the lowest carbon emissions.

A RIBA Stage 4 design is used, which is sufficient for a detailed assessment; however, it is still subject to development. A Hybrid Lifecycle Assessment model is developed which uses a combination of building quantities and carbon factors. The embodied carbon of each structure (Co2e) relative to its floor area (m2) produces an aggregated carbon emission for each stand (Co2e/m2). Lifecycle Assessments have industry standards but are open to interpretation. To address this bias, uncertainty ranges are demonstrated to improve the accuracy of calculation. This sensitivity analysis highlights the caution required in Lifecycle Assessment for embodied carbon in structural frames.

The results show that structural steel (900kgCO2e/m2) has greater embodied carbon than concrete (670kgCO2e/m2). A total of 752 carbon factors were found in the literature review, 508 of which are deemed appropriate for use. The material steel has a disproportionate impact on carbon emissions, with a 13% share of structural mass and a 40% share of embodied carbon when assessed in the North and South stands. Sensitivity analysis demonstrated uncertainty ranges greater in steel frames (459%) than concrete (351%); although significant in both. Concrete frames appear to have less carbon emissions than Steel, but the results are within a margin of error of 10% and should be determined equal. However, this challenges the hypothesis that concrete has the greatest carbon emissions in structural frames.

A surprise hypothesis found in this paper, is the lack of standardised calculation for embodied carbon, and the impact that has on the results. Without an agreed method of measurement, embodied carbon calculations are fraught with error. Achievement of nett zero emissions by 2050 requires an appreciation of the current position. The uncertainty ranges found in this paper indicate that there is only a vague grasp on present conditions.

The conclusion focuses on the importance of appropriate interpretation. This Lifecycle Assessment has been generated for a bespoke stadium; results should be interpreted with caution if they are to be used for other buildings.

This assessment offers numerous positive insights and great potential for reducing embodied carbon in the built environment; the hypothesis provides opportunities for future research. For industry, there is an opportunity to reduce embodied carbon if design solutions are addressed, rather than materials eliminated. Eradication of cement is a common goal across the industry; this paper challenges the design solution over the material selection. If the problem is viewed differently, the results could become more achievable. For academia, these results can inform future research into appropriate calculation methods for embodied carbon. Academia has a responsibility to challenge calculations and develop solutions which can be implemented across industry. This assessment demonstrates how acknowledgment of bespoke design is vital for production of appropriate results. If this is correctly interpreted, it can contribute to future research into embodied carbon calculation.

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May 2022