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Holistic study of a timber double skin façade: whole life carbon emissions and structural optimisation

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Abstract

The upkeep of existing buildings has a great role to play in reducing the carbon emissions of the built environment. Façade upgrade represents one of the most effective interventions to improve both thermal efficiency and aesthetic appeal of existing buildings. Double Skin Façades (DSFs) have much to offer due to their use of solar and wind energy to passively heat and cool indoor spaces, whilst guaranteeing freedom and flexibility in the aesthetic design of the refurbished building. However, DSFs also bear an increase in the embodied energy and carbon due to the additional materials required for the extra skin throughout all life cycle stages.

In this article, life cycle assessment (LCA) and dynamic energy modelling have been combined through a parametric approach to obtain figures for the whole-life cycle carbon assessment of 384 different configurations of an innovative, timber-made DSF for UK low-carbon refurbishments. Additionally, the structural design of the façade was also investigated through a structural optimisation procedure which takes into account all relevant loads and ensures minimal use of the structural material. Results show that operational savings outweigh the embodied impacts and therefore the proposed DSF is a viable and effective solution for net carbon-negative refurbishments. The operational energy modelling also contributes to the characterisation of DSFs thermal behaviour in temperate climates.

Keywords: Double Skin Façade; Structural Timber; Embodied Carbon; Whole life carbon; Energy savings; Life Cycle Assessment (LCA).

1. Introduction

Building-related carbon emissions in the UK total over 200 MtCO_{2e}, which represent more than 40% of the national figure [1]. Most of these emissions come from the operation of existing buildings, and are primarily related to the heating and cooling of indoor spaces [2]. Façades are at the interface between indoors and outdoors, and their improvement has been indicated as the most beneficial action for energy savings and carbon emission reduction [3].

This paper aims to investigate the potential of double skin façade (DSF) technologies as a means for low-carbon building refurbishments. DSFs are best suited to large, multi-storey buildings with clear demands for heating and cooling [4-6]. Therefore in this article their application to non-domestic refurbishments is examined. Non-domestic buildings in the UK are replaced at a very slow rate [7], with 75% of the non-domestic stock being built before 1985 [8]. Projections also indicate that 75-90% of them buildings will still be standing in 2050 [2].

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