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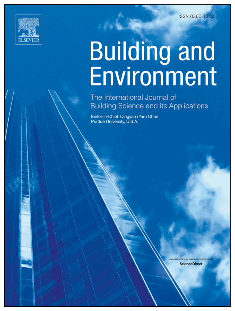

Life cycle assessment (LCA) of double-skin façade (DSF) system with fiber-reinforced concrete for sustainable and energy-efficient buildings in the tropics

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Life cycle assessment (LCA) of double-skin façade (DSF) system with fiber-reinforced concrete for sustainable and energy-efficient buildings in the tropics

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Abstract

Building envelope governs heat transfer between the external environment and building interiors and thus greatly influences the energy demand for heating and cooling. In this study, an innovative double-skin façade (DSF) system achievable with a new concrete composite called high performance green hybrid fiber-reinforced concrete (HP-G-HyFRC) is proposed. Mechanical performance and partial life cycle assessment (LCA) focusing on embodied and operational energy was evaluated for the new system against an existing solid façade (SW) system as generally adopted in public housing in Singapore. Flexural test results showed that in addition to a 25% reduction in concrete usage and weight, the DSF system also exhibited a higher structural capacity and ductility as compared to the SW counterpart. LCA analysis of a functional unit revealed that the DSF system could potentially reduce the annual operational energy and CO_{2eq} emission by 9.2%, despite a higher embodied energy and materials cost. Yet, the additional embodied energy and cost could be recovered within the first 2 and 8.2 years of operation, respectively. The findings demonstrate a promising potential for the application of the DSF system to reduce operational energy of buildings in the tropics.

Keywords: Double skin façade (DSF); fiber-reinforced concrete; life cycle assessment; sustainability; energy-efficient buildings

1. Introduction

Buildings are an integral part of the broader civil infrastructure that ensures our welfare, livelihood, safety and security. However, they also impose a number of sustainability challenges from inception to end of service life. Concrete, the most widely used construction material, has a relatively high embodied energy due to the energy intensiveness of cement which is commonly used as the main binder. Cement has an average carbon intensity of 900 $kgCO_2$/tonne [1]. With an annual global production of blended and unblended cement of 4.2 billion tonnes in 2016 [2] and an assumed clinker factor of 80%, the cement industry is estimated to emit approximately 3.0 billion tonnes or 6% of the 49.3 tonne total anthropogenic CO_2 emission [3]. During their operational phase, buildings also consume a considerable amount of energy. According to a Monthly Energy Review by US Energy Information Administration [4], residential and commercial buildings in the US consumed

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