

Environmental Impact Assessment of Self-Compacting Concrete Incorporating Steel Slag and Fabricated Sand: A Comparative Life Cycle Analysis

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Abstract

The construction industry is increasingly seeking sustainable alternatives to conventional concrete materials in response to growing environmental concerns, resource depletion, and the generation of industrial waste. This study presents an environmental impact assessment of Self-Compacting Concrete (SCC) incorporating steel slag and fabricated sand as partial or complete substitutes for conventional aggregates and natural sand. The objective is to evaluate the environmental performance of these alternative materials through a comparative Life Cycle Assessment (LCA). The study considers major environmental indicators, including energy consumption, greenhouse gas emissions, depletion of natural resources, and waste generation associated with the production and use of SCC. Steel slag, a by-product of the steel manufacturing industry, and fabricated sand produced from crushed rock materials have the potential to reduce dependence on natural aggregates and river sand while promoting the beneficial utilization of industrial and mineral waste. Different concrete mixtures are compared with conventional SCC to identify variations in environmental impacts across relevant life-cycle stages. The analysis also considers the relationship between environmental performance and concrete characteristics such as strength, workability, and durability. The study aims to demonstrate whether the incorporation of steel slag and fabricated sand can contribute to more sustainable concrete production without compromising essential performance requirements. The findings are expected to support environmentally responsible material selection and encourage resource-efficient practices in the construction sector. The study highlights LCA as a useful framework for evaluating sustainable concrete technologies and guiding future low-impact construction practices.

Keywords: Self-Compacting Concrete, Steel Slag, Fabricated Sand, Life Cycle Assessment, Environmental Impact, Sustainable Construction, Green Concrete, Natural Resources, Carbon Emissions, Waste Utilization, Construction Materials, Sustainability.