Economic and Environmental Feasibility of Hybrid Concrete Incorporating Steel Slag and Rice Husk Ash: A Path Toward Green and Circular Construction Finance

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Abstract

The concrete industry remains a major contributor to global CO_2 emissions, primarily due to the production of Ordinary Portland Cement (OPC). This study examines the financial and environmental viability of hybrid concrete incorporating steel slag (SS) and rice husk ash (RHA) as sustainable supplementary cementitious materials (SCMs). A combined techno-economic and life cycle assessment (LCA) framework was developed to evaluate mechanical performance, durability, embodied carbon reduction, and cost efficiency. The optimal mix containing 15% SS and 10% RHA not only achieved a 6.7% higher 28-day compressive strength compared to the OPC control but also demonstrated a 42.5% reduction in CO_2 emissions and a 12.8% decrease in production costs. The results highlight how valorizing industrial and agricultural by-products in concrete can enhance investment returns, reduce carbon liabilities, and support the transition toward circular and low-carbon construction financing. This study provides insights for policymakers, investors, and construction firms in integrating sustainable materials into green finance frameworks.

Keywords: Steel slag, Rice husk ash, Hybrid concrete, Supplementary cementitious materials, Life cycle assessment, Cost efficiency, Circular economy, Sustainable construction.