Environmental Engineering and Management Journal

April 2026, Vol. 25, No. 4, 943-958
http://www.eemj.icpm.tuiasi.ro/; http://www.eemj.eu
http://doi.org/10.30638/eemj.2026.072

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LIFE CYCLE ASSESSMENT OF ALTERNATIVE CONCRETE PAVEMENT MATERIALS INCORPORATING INDUSTRIAL BY-PRODUCTS

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Abstract

The construction industry faces pressure to adopt sustainable practices, especially due to the high CO_2 emissions from cement production in concrete. This study uses a cradle-to-gate Life Cycle Assessment (LCA), following ISO 14040/14044, to evaluate alternative concrete pavement materials incorporating industrial by-products. Using SimaPro with the Ecoinvent v3.3 database and ReCiPe 2016 method, several scenarios were compared: a control (A0), partial cement replacements with silica fume (A3) and fly ash (A6), and aggregate replacement with steel slag (G1). Cement was the dominant environmental hotspot, accounting for up to 98% of the impacts in the control mix. Fly ash (A6) offered the broadest environmental benefits, especially in reducing toxicity impacts. Silica fume (A3) lowered carbon emissions but increased toxicity. Steel slag (G1) also reduced toxicity and eutrophication. The results highlight the environmental benefits of using industrial by-products in concrete, supporting circular-economy goals and informing sustainable construction practices.

Key words: concrete pavement, fly ash, Life Cycle Assessment (LCA), silica fume, steel slag

Received: January, 2026; Revised final: February, 2022; Accepted: March, 2022; Published in final edited form: April, 2026

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