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Concrete and Cement-Based
Composites for Sustainable Built
Environments

Editors:
Kimberly Waggle Kramer, Milena Rangelov,
and Hessam Azarijafari



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Concrete and Cement-Based Composites for Sustainable Built Environments

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Concrete and Cement-Based Composites for Sustainable Built Environments

Concrete has played a pivotal role in shaping the modern world's infrastructure and the built environment. Its unparalleled versatility, durability, and structural integrity have made it indispensable in the construction industry. From skyscrapers to long-span bridges, water reservoirs, dams, and highways, the ubiquitous presence of concrete in modern society underscores its significance in global development. As we stand at the crossroads of environmental awareness and the imperative to advance our societies, the sustainability of concrete production and utilization is becoming a new engineering paradigm.

The immense demand for concrete, driven by urbanization and infrastructure development, has prompted a critical examination of its environmental impact. One of the most pressing concerns is the substantial carbon footprint associated with traditional concrete production. The production of cement, a key ingredient in concrete, is a notably energy-intensive process that releases a significant amount of carbon dioxide (CO_2) into the atmosphere. As concrete remains unparalleled in its ability to provide structural functionality, disaster resilience, and containment of hazardous materials, the demand for concrete production is increasing, while at the same time, the industry is facing the urgency to mitigate its ecological consequences.

This special publication investigates the multi-faceted realm of concrete sustainability, exploring the interplay between its engineering properties, environmental implications, and novel solutions, striving to provide an innovative and holistic perspective.

In recent years, the concrete industry has witnessed a surge of innovation and research aimed at revolutionizing its sustainability. An array of cutting-edge technologies and methodologies has emerged, each offering promise in mitigating the environmental footprint of concrete. Notably, the integration of supplementary cementitious materials, such as calcined clays and other industrial byproducts, has gained traction to reduce cement content while enhancing concrete performance. Mix design optimization, coupled with advanced admixtures, further elevates the potential for creating durable, strong, and eco-friendly concrete mixtures.

Concrete practitioners will gain an advanced understanding of a wide variety of strategies that are readily implementable and oftentimes associated with economic savings and durability enhancement from reading these manuscripts. The incorporation of recycled materials, such as crushed concrete and reclaimed aggregates, not only reduces waste but also lessens the demand for virgin resources. Furthermore, the adoption of efficient production techniques, along with the exploration of carbon capture and utilization technologies, presents an optimistic path forward for the industry.

This special publication aspires to contribute to the ongoing discourse on concrete sustainability, offering insights, perspectives, and actionable pathways toward a more environmentally conscious future.

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Functional Equivalency in the Comparative Life Cycle Assessment of Solid Waste Concrete: Implication of Mechanical Performance and Durability

Alireza Haji Hossein, Hessem AzariJafari, Rahil Khoshnazar

Synopsis: Portland cement concrete has shown great potential for recycling different waste materials. Solid waste incorporated concrete (SWC) is considered to have positive environmental advantages. However, the utilization of solid wastes may negatively impact the mechanical performance and durability of concrete. Therefore, any change in the performance metrics of SWC should be accounted for in the comparative life cycle assessment (LCA). This article will review the functional equivalency with respect to the mechanical performance and durability metrics for SWC incorporating four main streams of solid wastes; recycled concrete aggregate, municipal solid waste incineration ashes, scrap tire rubber, and polyethylene terephthalate. It will be shown that while in most cases, SWC may have an inferior compressive strength and/or durability pre-treatment, sorting, and appropriate replacement rate of the solid wastes may solve the problem and make SWC functionally equal to the conventional concrete. Moreover, some types of SWC such as those incorporating scrap tire rubber and polyethylene terephthalate may be more advantageous if used in specific applications where dynamic loads are prevalent given their superior impact resistance. Finally, the article will discuss new insights into defining the functional unit based on the performance and application of SWC to conduct a reliable LCA.

Keywords: Solid waste concrete, Life cycle assessment (LCA), Recycled concrete aggregate (RCA), Municipal solid waste incineration (MSWI), Scrap tire rubber (STR), Polyethylene terephthalate (PET)