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Special Issue - Decarbonization of materials and construction processes | Editorial note

Edición Especial - Descarbonización de materiales y procesos de construcción | Nota Editorial

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The construction industry accounts for approximately 39% of global greenhouse gas emissions, making it a key sector in addressing the Net Zero Emission by 2050 Scenario (Blanco et al., 2021; iea & UN, 2019; iea, 2024; Murtagh et al., 2020). The decarbonization of this sector is urgent, for instance, 30% of global final energy consumption stems from the operation of buildings (iea, 2024). In addition, structural fragmentation and complex value chains have historically posed barriers to sustainability in construction (Murtagh et al., 2020). Furthermore, recent studies emphasize that collaborative initiatives, such as integrating stakeholders from design to reutilization, are essential for decarbonizing the sector (Blanco et al., 2021). Thus, the decarbonization challenge poses a complex scenario that requires the development of innovative solutions but also requires the acceleration of practical implementations.

In this context, **Revista Ingeniería de Construcción** is pleased to publish its Volume 39 Special Issue "**Decarbonization of Materials and Construction Processes**". This publication is the final product of the work of a group of academics and practitioners from Canada, Brazil, Chile, Germany, and Spain. They have provided valuable contributions on topics related to some of the major and nobel decarbonization trends that currently are impacting the sustainability of the construction industry.

This special issue covers various topics relevant to decarbonization. These include aspects such as the ***decarbonization of Construction Materials*** focused on the reduction of carbon emissions through alternative materials and cement replacements, ***innovations in recycling technologies*** that explore recycling processes and circular economy approaches for sustainable construction, ***sustainability in material design and performance,*** a theme that highlights advancements in designing materials that combine sustainability and improved performance, ***waste and by-products in construction***, where the emphasis is on the use of industrial by-products and waste materials to enhance sustainability and ***quality assurance and pavement preservation*** focused on ensuring the durability and efficiency of infrastructure through enhanced quality assurance.

Thus, beginning with decarbonization of construction materials, the following featured articles are included in the special issue:

- Professors Harald S. Müller and Michael Haist in "***Design approaches for sustainable concrete mixes and structural components"*** discuss the fundamental approaches for the development of sustainable concrete, in this article, the authors introduce the Concrete Sustainability Potential (CSP) metric. This new parameter integrates environmental impact, service life, and performance; their findings emphasize the balancing of environmental impact, durability, and performance, presenting practical strategies for green concrete applications in future construction.

- Laura Silvestro, Rodrigo Scoczynski Ribeiro, and Ivan Navarrete in "***Advancements in low carbon emission cements for 3d printing: a state-of-the-art review"***, address the challenges generated by the adoption of the 3D-printed concrete (3DPC), due to the use of low-carbon binders -in particular, calcium sulfoaluminate (CSA) cement, limestone calcined clay (LC3) cement, and geopolymers-. Their findings provide

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a synthesis of the effects of these binders concerning their use in 3DPC, on aspects of concrete such as fresh properties, mechanical performance, and durability.

- De la Varga Igor, Sargam, Yogiraj and Alexio, and Daniel Martins In ***"CO_2 Mineralization in the production of sustainable concrete"***, investigate the use of CO_2 mineralization in concrete production. The study analyzes the impact on key properties of concrete. The findings reveal that CO_2 mineralization allows the achievement of an equivalence strength with reduced cement content and lower embodied carbon. Thus, it is concluded that CO_2 mineralization represents a transformative approach to reducing the impact of concrete production, in line with decarbonization and sustainability objectives for the industry.

Then, concerning innovations in recycling technologies:

- Ivan Navarrete, Nikola Tošić, José Luís Hermida, Ruth Saavedra, and Miren Etxeberria in ***"3D Printed concrete as a source of recycled aggregates: Potential for multi-recycling and CO_2 sequestration"***, address the circularity and recyclability of additive manufacturing of concrete (3D Printed Concrete, 3DPC). In their study they evaluate the viability of recycling 3DPC, using normal and high strength types of concrete which includes fine recycled aggregates (fRA), for multi-recycling potential. Their findings suggest that 3DPC enables high recyclability and CO_2 sequestration through carbonation.

- Felipe Vargas and Guillermo Rios in *"**Use of artificial fine aggregates from copper tailings in mortar: Mechanical performance",*** considered the context of the mining industry and the generation of cooper mine tailings – a significant issue in this sector-, address the development of artificial fine aggregates (AFA) using cooper tailings through alkaline activation. The study evaluates the impact of AFA on mortar mixtures. Their findings reveal that replacement levels of up to 45% improve mechanical performance and reduce the density of mortars. They conclude that using their methodology, it is possible to manufacture artificial fine aggregate by alkaline agglomeration.

Next, on sustainability in material design and performance:

- Zichun Xia, Chengkai Wang, and Leandro Sanchez in "***The influence of Interground limestone fines and metakaolin on the electrical resistivity of portland-limestone concrete"*** address the decarbonization of Portland ordinary cement (OPC), through the use of Portland limestone cement (PCL) -i.e., a product obtained by partially replacing clinker with interground limestone fines (LFs). Nonetheless, the strategy may involve some issues detrimental in the long term to the performance of reinforced concrete structures. In this context, this study analyzes the use of PLC and alumina-rich supplementary cementitious materials (SCMs). The findings revealed that using metakaolin (8%) -as a source of alumina in PLC-, can notably improve concrete´s resistivity, while compressive strength exhibits poor correlation with electrical resistivity. This condition underscores the relevance of performance-based design.

- Xiomara Sánchez, Xiomara, and Sina Varamini, in ***"Effect of biochar type in the performance of biochar-modified binder"*** evaluate the impact of biochar - i.e., a biomass sub-product- on asphalt binders. Their work reveals findings such as increased viscosity, and reduced penetration, whereas rheological analysis suggests improved rutting resistance, reduced cracking resistance, and ultimately altered oxidative aging. Hence, they conclude biochar type and dosage significantly influence the performance of binders, hence optimizing these factors can balance benefits and limitations, advancing sustainable binder applications with carbon offset potential.

After, waste and by-products in construction:

- Tomás Delgado García, José F. Altschwager, and Alvaro Paul in **"*Use of reclaimed fly ash for the production of sustainable cementitious composites*"**, assess the use of Reclaimed Fly Ash (RFA) as a sustainable replacement of ordinary Portland cement (OPC) in engineered cementitious composites (ECC) mixtures. The study tests the tensile properties of RFA-ECC with varying OPC replacement levels and fiber content. The findings reveal that RFA-based ECC can achieve high tensile strength and ductility. The authors conclude that RFA is a feasible and sustainable alternative to OPC in ECC.

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- Alejandro Ríos, Martin Nöel, and Marcelo González in "***The potential of using Chilean biomass to develop insulating biocomposite material",*** considering the context of improving building energy efficiency through insulation materials, identify, and explore the use of natural fibers most produced in Chile as Biocomposites for creating sustainable insulation materials with a low carbon footprint.

Finally, quality assurance and pavement preservation:

- Professor Peter Sebaaly, in "***Sampling and testing for quality assurance of pavement preservation and treatments"***, studies the development of reliable QA tools for slurry systems, focusing on the device of asphalt felt sampling and oven tests. The study´s findings show that accurate measurements of water and residue content, enhance compliance and pavement durability. Improved QA ensures better long-term performance and safety in road infrastructure.

We hope that the articles presented in this special issue will contribute to stimulating further research, collaboration and implementations. The discussed topics are highly relevant to the industry´s needs concerning sustainability (Lima et al., 2021).

The transition to sustainable and resilient construction is an opportunity the industry must seize to meet global decarbonization goals. This edition emphasizes that decarbonization is not just about reducing emissions but also transforming practices to enhance operational efficiency(Balland et al., 2022; Ntakana et al., 2024). As highlighted in this issue, research and innovation concerning materials and construction processes play a crucial role in accelerating the transition. We invite all stakeholders in the sector to join this effort, contributing to a built environment aligned with 21st-century challenges.

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Declaration of generative AI and AI-assisted technologies

While preparing this work, the authors used ChatGPT to improve the draft´s style. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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