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Editorial: Supplementary cementitious materials: recent developments, performance insights and potential applicability

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Editorial on the Research Topic
Supplementary cementitious materials: recent developments, performance insights and potential applicability

Introduction

The construction industry must rapidly develop and adapt to meet sustainability and environmental demands because it is a major consumer of raw materials and is an important driver of greenhouse gas emissions worldwide. In view of their dual function in improving concrete's mechanical characteristics and tackling important environmental issues, supplementary cementitious materials (SCMs) such as fly ash, slag, and silica fume have grown in importance in this context. The conventional cement manufacturing method uses a significant amount of natural resources and produces a high volume of carbon emissions; however, these materials, which are usually byproducts of other industrial operations, provide an effective alternative.

The workability, heat of hydration, and long-term strength and durability of concrete are all improved by SCMs. By enhancing the total density of the matrix and filling in the microstructure, studies have demonstrated that fly ash added to concrete increases its compressive strength and durability (Luan et al., 2023). For instance, the hydraulic properties of a byproduct of iron production, "slag," have been the subject of extensive research. These properties enable slag to react with water, aiding in the hydration process and ultimately producing

denser and more durable concrete (Fu et al., 2023). Other beneficial SCMs include silica fume, which improves the mechanical characteristics and durability of concrete by reducing porosity and strengthening the bond between aggregates and cement paste (Saradar et al., 2024).

This Research Topic focuses on highlighting the innovative applications and cutting-edge research surrounding SCMs. By showcasing studies that explore the utilization of these materials in various concrete applications, this issue aims to illustrate the broad potential and significant impact of SCMs on modern construction practices. The contributions to this Research Topic reflect ongoing advancements in the field and underscore the growing importance of sustainable material solutions in construction, emphasizing their role in not only meeting but exceeding the performance expectations of traditional construction materials.

This Research Topic aims to offer a forum for knowledge exchange and discussion on the remarkable impact of SCMs in the construction sector through in-depth research and case studies. Its goal is to facilitate additional research and wider use of these materials, thereby encouraging a global transition to more resilient and sustainable building solutions.

Significance and future directions

The current direction of the building industry is defined by the necessity of balancing the competing objectives of structural integrity and environmental sustainability. Supplementary cementitious materials (SCMs) have the potential to be revolutionary in this environment. SCMs do more than only improve the physical qualities of concrete; they also reduce the overall carbon footprint of construction projects and repurpose industrial byproducts, keeping them out of landfills and promoting sustainable development. The knowledge gained from this Research Topic highlights the variety and depth of SCM applications, proving that they can meet stringent structural and environmental guidelines.

In the future, incorporating SCMs into hybrid composites will offer a substantial opportunity for expansion. These composites can meet environmental regulations while achieving previously unprecedented performance metrics by blending SCMs with both conventional and innovative materials. The field of research in this area is growing, with an emphasis on maximizing the synergistic benefits of different material combinations to improve the mechanical qualities, durability, and permeability of concrete (Ocelić et al., 2024). A paradigm shift in resource utilization is also represented by the employment of SCMs in the context of a circular economy, where the objective is to regenerate value in addition to reusing materials. This strategy pushes the boundaries of what is technically and financially possible in construction methods, which is in line with global sustainability goals.

However, there are challenges to the future of SCM. Although the advantages of SCMs for sustainability and performance improvement are well known, problems such as quality variability, supply availability, and the technical difficulties of incorporating them into fresh concrete mixes continue to be an issue (Barbhuiya et al., 2024). It will take a concerted effort in research, standardization, and innovation to overcome these challenges. To guarantee that the solutions developed are efficient, scalable, and financially viable, a multidisciplinary strategy involving cooperation between materials scientists, engineers, legislators, and industry stakeholders is required.

The development of building materials will be significantly influenced by the ongoing innovation and research in SCM technology. The trend indicates that materials will become more intelligent, sustainable, and highly adaptable to the changing needs of the global environment. As we confront the growing issues of urbanization, climate change, and the need for long-lasting infrastructure, this advancement is crucial. As a result, the continued study of SCMs is not only a technological undertaking but also a vital one in the pursuit of sustainable development of the built environment.

A total of five articles were published in this Research Topic, which is briefly summarized in this editorial.

The first manuscript submitted to this Research Topic, "Concrete Matrix Based on Marble Powder, Waste Glass Sludge, and Crumb Rubber: Pathways towards sustainable concrete" was published by Akbar et al. This study explored the development of sustainable concrete by integrating marble powder, waste glass sludge, and crumb rubber, aiming to reduce environmental impact while maintaining structural integrity.

Shahzad et al. examined how varying print speeds and nozzle diameters affect fiber alignment in 3D printed ultra-high-performance concrete, providing insight into optimizing mechanical properties through controlled printing parameters.

Wang et al. presented the bibliometric study that maps out the research trends and emerging hotspots in the field of polymer cement mortar, offering valuable insights into its development and future directions.

Özkılıç et al. investigated the incorporation of waste ceramic powder as a supplementary cementitious material in concrete, with the aim of enhancing sustainability by reducing reliance on conventional cement and promoting waste utilization.

Zuo et al. investigated the effect of varying lengths of polypropylene fibers and the geometric shapes of samples on the uniaxial compressive strength (UCS) of cemented lepidolite tailings backfill (CLTB). The findings revealed that a fiber length of 12 mm yields the highest UCS, with an improvement of up to 83.7% compared to non-fiber-reinforced samples. These insights offer practical guidance for optimizing fiber-reinforced backfill materials in mining and construction applications.

Conclusion

It is clear from this Research Topic on "Supplementary Cementitious Materials: Recent Developments, Performance Insights, and Potential Applicability" that SCMs have the ability to revolutionize the building materials industry. The contributions to this Research Topic not only offer a thorough explanation of the various uses of SCMs but also highlight their importance in the global advancement of sustainable building strategies. The breadth of research shows that SCM technology is dynamic and ever-evolving, demonstrating its ability to address urgent environmental issues and improve the structural soundness of concrete facilities.

By promoting their incorporation into standard procedures as a crucial first step in creating robust and environmentally sustainable infrastructure, the creative application of SCMs is setting a new course for the construction industry. The ideas presented in this issue are intended to serve as an inspiration for further study and wider use of SCMs, pushing the boundaries of innovation in this important field. As we move forward, the combined efforts of the international research community are crucial to meeting the complex guidelines of modern construction, making great strides toward sustainability, and improving the efficiency of construction methods. This Research Topic lays out a roadmap for the next investigations and developments in the field, marking a significant turning point in this ongoing journey.

Author contributions

AK: Writing – original draft, Writing – review and editing. AF: Writing – original draft, Writing – review and editing. PA: Writing – original draft, Writing – review and editing. IA: Writing – original draft, Writing – review and editing. CR: Writing – original draft, Writing – review and editing. MH: Writing – original draft, Writing – review and editing.

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Conflict of interest

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Generative AI statement

The authors declare that no Generative AI was used in the creation of this manuscript.

Publisher's note

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