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Editorial: Volume stability and durability of alternative and sustainable binders

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Editorial on the Research Topic
volume stability and durability of alternative and sustainable binders

This Research Topic was initiated to attract new research outcomes on volume stability and durability of sustainable binders, with the aim to contribute to the tackling of Research Topic hindering a wider application of low-carbon building materials. Cement-based concrete has shown acceptable mechanical properties and durability in infrastructures, but the carbon footprint involved in the production of cement is of high concern. Both research and industrial sectors are exploring alternative binders with lower energy consumption and CO_2 emission. However, larger shrinkage and poorer durability compared to traditional cement are sometimes identified for these new binders, which should be addressed if they are to be used in practical applications of structural engineering.

In this topic, we have gathered five articles on various aspects of alternative and sustainable binders. Three of them are on alkali-activated materials (AAMs), one is on oil well cement, and the other one is on bacteria-incorporated cement. The three articles on AAMs are focused on mixtures made from different precursors including alkali-activated slag (AAS), alkali-activated slag-fly ash (AASF) systems, and alkali-activated slag-metakaolin (AASM).

The paper by Lacante et al. focused on the autogenous and thermal deformations of the AASF system, which is currently a commonly used AAM. While its drying shrinkage has been intensively investigated in the literature, autogenous and thermal deformations of AAMs require a better understanding. In particular, this paper should be one of the few papers so far concerning the thermal deformation of AAMs. With comprehensive experimental work, this study found that both autogenous shrinkage and thermal deformation of AASF are much higher than those of Portland cement (PC). A smaller liquid-to-binder ratio would result in higher autogenous shrinkage but a lower coefficient of thermal expansion (CTE). Interestingly, a striking linear relationship was identified between the autogenous strains and reaction heat, which motivates a deeper analysis of the origin behind them.

Metakaolin (MK) is another widely used aluminosilicate precursor for AAMs. However, knowledge is still lacking regarding the mixture design of slag-metakaolin-based systems. The paper Zhan et al. proposed a new mathematical model based on Box-Behnken RSM method to optimize the mix proportions of AASM. Experimental and modeling results

demonstrated that the dominant factors affecting the compressive strength and autogenous shrinkage were interactions of Na_2O and activator to MK content, respectively, of AASM. Under the interaction of Na_2O and metakaolin contents, the OH^- and Na^+ in the solution react with $A1^{3+}$ and Si^{4+} to generate more N-A-S-H, which reduces the compressive strength of the composite system but decreases autogenous shrinkage and increases volume stability.

Unlike slag, fly ash and metakaolin, agricultural waste can also be used as an additive or even precursor in AAMs. The paper by Yin et al. investigated the properties of one-part AAS, also called "just-add-water" AAS, with the incorporation of rice straw powder. Without the use of a liquid activator, which is toxic and inconvenient to store and transport, one-part AAS is easier and safer to prepare by workers. The shrinkage of one-part AAS is much lower than two-part AAS, but is still higher than PC system. With the addition of rice straw powder, the shrinkage of one-part AAS is greatly reduced, while the compressive strength is marginally reduced. The flexural strength is even improved. These results indicate good feasibility of blending rice straw powder into AAS, which can not only enhance the utilization of agricultural waste but also improve the performance of AAS.

Volume stability is important for not only AAMs but also for special-purpose cement, such as oil well cement. The study by Song et al. investigated creep as a key factor affecting the casing deformation of oil well cement. The effects of different additives, such as retarder, glass fiber, and CSA expansive agent were explored. The results showed that retarder plays a negative role in reducing creep deformation, while glass fiber is beneficial. CSA, as a commonly used cement compound, is considerably effective in limiting the creep deformation of oil well cement paste at early ages. The outcome of this study could be a useful reference for researchers and engineers in this field.

The paper by Bandlamudi et al. is on bacterial self-healing which can sustainably improve the durability of PC concrete. As a review paper, this study covers the permeation properties, water absorption, and mechanical properties of concrete with bacterial inclusion. The morphological analysis of $CaCO_3$ precipitation to repair cracks in concrete is discussed. It is shown that bacteria have a limited active life span during the direct addition process, which limits self-healing efficiency but increases the strength properties of concrete. To extend the life of bacteria, various encapsulating strategies have been tried and polymer-based encapsulation is the most widely used self-healing option. Along with bacterial concrete, the use of extra nutrients in concrete is gaining popularity as a new self-healing approach. Future research is suggested to concentrate on combining these extra cementitious materials with encapsulated microorganisms, which could be a viable solution for improving self-healing efficiency.

The five published studies on this topic, cover volume stability and durability of different sustainable building materials. The statistics show that our volume received more than 11k views and 372 downloads over 3 months from the last paper published (19 January 2023). We believe the insights provided in these papers are helpful to enhance the sustainability of the building sector. We hope that readers find them interesting to read. We would also like to take the chance to acknowledge the authors of this topic for their great contribution.

Author contributions

ZL: Writing-original draft. XZ and AK: Writing-review and editing. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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