How to predict strength and optimum mix-designs of mineral-waste-based geopolymers

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Reducing the carbon footprint of building material production (*ca.* 9 % of anthropogenic CO_2) in the short term is essential to achieve global climate targets. In this regard, mineral wastes and industrial secondary raw materials show large potential as a low-CO_2 alternative to traditional carbonate-based binder systems. In order to promote and establish the use of mineral waste based binders as strong future competitors in the construction industry, optimal combinations of solid and liquid binder components have to be developed in so-called mix designs to meet material requirements. In this context, the desired material properties, such as adequate workability, high strength, improved chemical resistance and minimal shrinkage strongly depend on elemental ratios (*e.g.* Si/Al, Al/K) within the mix design. These are multi-variable challenges that are conventionally solved by changing one variable of the mix design at a time, until the desired results are achieved. In order to ensure a more time-and cost-efficient strategy, and to generate optimum experimental conditions, we are applying the Design of Experiment (DoE) and Response Surface Methodology (RSM) approaches to alkali-activated waste-based binder systems. DoE is a widely used procedure that seeks to predict a desired outcome (*e.g.* compressive strength, elemental ratios), which is then systematically optimized by a set of statistical techniques (RSM). In the current study, we evaluated the most desirable relative contents of the mix design components metakaolin, mineral wastes and aqueous potassium silicates (waterglass as alkaline activator) under the conditions of (i) maximizing the content of mineral wastes and (ii) achieving the desired material properties (e.g,. compressive strength). Preliminary results demonstrate how a minimum number of experimental runs and samples enables a refinement of possible mix-ratio-combinations. Re-iterations of these experimental procedures allow to accurately predict relevant material properties such as mechanical performance of the hardened mineral-waste-based binder material. Additionally, economic and ecological decisions could be already made during early stages of experimental approaches by including manufacturing costs and CO_2 emissions to the existing DoE models.