Metallurgic slag-based geopolymer materials in the circular economy

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Metallurgic slag production in Austria reaches values of 2.8 Mio. t/a, from which 736,000 t/a are currently disposed in landfills. In this context the utilization of the latter in mineral-based construction materials exhibit high potential to increase material circularity, as well as to reduce the environmental impact of construction material production. To date, blast furnace slag (BFS) is the only type that is used in ordinary Portland cement-based (OPC) building materials as aggregate and/or supplementary cementitious materials (SCM), or within geopolymer (GP) applications. Other slags have lower hydraulic reactivity than BFS, which limits their application as SCMs in OPC. Additionally, slags frequently contain higher contents of unwanted elements (e.g. heavy metals), potentially raising environmental concerns when directly supplemented in large quantities in OPC applications. This work presents fundamental feasibility studies on the usage of different, so far industrially unexploited, metallurgic slags from Austrian iron and steel production to be used as a binder in GP materials. Various paste and mortar samples were produced with a slag content between 46 and 93 wt.-% (of binder/solid content). Several mixtures reveal good workability and very high compressive and tensile strength development of up to 100 MPa and 10 MPa after 28 days, respectively. Laboratory acid tests (8 weeks of sulfuric acid attack; pHstat = 2) conducted on several of these mortar formulations exhibited significantly improved durability versus conventional OPC-based high-performance concrete according to standard regulations. These results highlight the overall potential of utilizing metallurgic slags to produce green and sustainable GP-based construction materials.