COMPARING NEW TESTING METHODS FOR THE SULFATE RESISTANCE OF SHOTCRETE

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Shotcrete is one of the essential building blocks of modern excavation and tunnelling methods. In these underground settings shotcrete frequently comes into contact with aggressive solutions and can be chemically attacked and damaged which may necessitate expensive refurbishing efforts. A deeper understanding of the mechanisms of deleterious chemical attacks on concrete is necessary to better predict long-term performance and durability of newly developed concrete mixes. Sulfate attack is one of the major chemical threats to shotcrete, leading to weakening and in extreme cases disruptive expansion of the cement matrix.

We compare the performances of 7 dry-mix shotcrete mix designs using different amounts and types of supplementary cementitious materials (SCM) in a novel sulfate resistance test for concrete using powdered samples (STEINDL et al., 2019) and in a modified sulfate expansion test specified in SIA 262/1:2013 (SIA, 2013). In the former test, powdered samples are used instead of prisms or drill cores to better decipher alteration reactions and to eliminate and indirectly assess the influence of variations in microstructure or porosity. Chemical (XRF, IC, ICP-OES) and mineralogical (FTIR, XRD) analyses of the reactive solutions and solids show that the mineral reactions during the experiment are dominated by the dissolution of portlandite, Ca-leaching from C-S-H and the precipitation of calcite and ettringite. The test is coupled with thermodynamic modelling of the reactive fluids to understand precipitation mechanisms and assess stability relations between hydrated solid phases. Our results show marked differences in the reactivity of the mixes and the amount of precipitated secondary calcite and ettringite.

In the second test setup, the sulfate-related expansion of drill cores in a 5 wt. % Na_2SO_4 solution is measured. The setup revealed the important influence of the type and amount of SCM used, with mixes containing high amounts of blast-furnace slag showing lower expansion than mixes with low amounts of either blast-furnace slag or metakaolin.

Comparing the results of both test methods provides advanced insights into concrete damaging mechanisms in sulfate-loaded environments. This helps to identify the best-performing mix designs to develop more durable and sustainable shotcrete in the research project “ASSpC - Advanced and Sustainable Sprayed Concrete”.

STEINDL, F.R., BALDERMANN, A., GALAN, I., SAKOPARNIG, M., BRIENDL, L., DIETZEL, M., MITTERMAYR, F. (2019): Constr. Build. Mater., 223, 55-68.
SIA (2013): SIA 262/1:2013. Schweizerischer Ingenieur- und Architektenverein, Zürich.