Summary

Damage potential due to increased sulfate content by use of alkali-free accelerators in shotcrete

By use of alkali-free accelerators in shotcrete for constructional engineering (e.g. at slope protections, in tunnel construction, etc.) several problems that arose with alkaline accelerators could be solved. The alkali-free accelerators have advantages compared to the traditional alkaline products particularly in terms of reduced leachability as well as early and ultimate strength. Alkali-free accelerators are usually produced on basis of aluminium hydroxide and sulfate. The reaction mechanism of these accelerators is based on the increased formation of ettringite in the fresh sprayed concrete. With a usual dosage of about 4.0 to 8.0 % of the weight of cement the concrete is provided with an additional sulfate amount, which is already in the order of magnitude of the maximum permitted sulfate content according to DIN EN 197-1. Therefore the potential for a damaging formation of ettringite and/or thaumasite is approximately doubled in terms of sulfate. To what extent this potential in the shotcrete actually leads to damage has not been examined so far yet.
The aim of the research project was to investigate to what extent the increase of the sulphate content by the use of alkali-free accelerators may impair the durability of shotcrete. The investigations focused on the damage potential due to the increased sulfate content in the hardened concrete with consideration of the specific pore structure of shotcretes.
In this research project 8 plates of shotcretes differing in type of cement, alkali-free accelarator and dosage were manufactured in the shotcrete rig of the Ruhr-Universität Bochum under site-conditions. Several drilling cores taken out of the sprayed plates were stored in sulphate solution (0.22% Na_2SO_4), water and air at 8 °C for one year. During this period the compressive strength, the variation of length and the ultrasonic speed as well as the damage mechanisms and their degree (cracks, deterioration of microstructure, etc.) using scanning electron microscopy and element analysis were determined at different points in time.
After a duration of 360 days in water or in sodium sulfate solution no damage of microstructure as a consequence of a formation of secondary ettringite or thaumasite could be observed neither macroscopically nor microscopically on the shotcretes with different alkali-free accelerators. A differentiation of the different types of accelerators as well as a limitation of the dosage amounts regarding a sulfate attack are not possible on basis of the present results.
The primary formation of ettringite by the effect of accelerator is obviously completed to a large extent with the setting and the following storage in water at 20 °C. A formation of ettringite later on during the permanent storage at 8 °C takes place generally in the pores of the shotcrete only and causes thereby no damaging stresses in the microstructure. The homogenous distribution of the liquid accelerators in the matrix of the concrete and the typically higher porosity of shotcrete favour the development of a microstructure with low stresses. The observed increase of the dynamic elastic modulus may be attributed in the first instance to the ongoing filling of the pores during the storage. On basis of the present results a hazard potential and finally a negative influence on the durability of shotcrete by the use of alkali-free accelerators that correspond to the investigated products can not be deduced.

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