Performance of alusilica as mineral admixture in cementitious systems

The aim of this project is to study the effect of alusilica (ALS) as a mineral admixture on the fresh properties and development of mechanical properties of cementitious systems. ALS consists of relatively pure, amorphous silicon-dioxide – a chemical compound which is known to be useful as mineral admixture in concrete. The project has been carried out in cooperation with the company alufluor (Helsingborg, Sweden), and MSc Ebbe Skyum Jøns.

The application of ALS was investigated as partial cement substitution in mortar. A total of three mortar mixtures were produced: 1) reference, i.e. no substitution of cement, 2) cement clinker and gypsum substituted partly with ALS before grinding (referred to as “co-ground”), and 3) cement (i.e. ground cement clinker and gypsum) partly substituted with ALS and subsequently blended (referred to as “blended”). The level of substitution was 10% ALS relative to the total binder mass (cement+ALS). The water/binder-ratio (w/b) is 0.5 for all mixtures. The produced ALS-substituted powder was studied by scanning electron microscopy (SEM) and Energy Dispersive X-ray Analysis (EDAX) to investigate if the ALS agglomerates in the raw material were broken by the grinding procedure.

On the fresh mortar air content was measured by the pressure method, ASTM C231/C231M-14 and the flow was measured by ASTM C1437-13. Casting was done in standard mortar molds 4×4×16 cm3. After demolding, each mortar specimen was weighed over and under water to evaluate their homogeneity and air content, and subsequently they were immersed in lime water until further testing. Mechanical testing generally followed EU standard EN 196-1. In accordance with the EU standard, measurements of mechanical properties were done at a minimum of 3 samples at each test time 1, 2, 3, 7, 14, 28, 56 and 112 days. On hardened samples air content was additionally measured by point counting.

The inclusion of ALS in the mortar as a mineral admixture with the cement substitution ratio of 10% resulted in a higher air content and lower flowability in comparison with the reference mortar. Compared with blending ALS during mixing, mortar containing co-ground ALS has properties closer to the reference mortar. ALS substitution seems to only have a minor effect on the flexural strength throughout the hardening. Mortar with ALS substitution, exhibited a lower compressive strength as compared to the reference mortar. However, a major part of this strength reduction seems to be caused by the lower flowability and the related higher air content. The ALS substituted systems may potentially be optimized through adjustment of a plasticizing agent, and in that case there is not expected to be a strength reduction. It is concluded that ALS can be a useful cement substitution.

For further tests it might be relevant to investigate the performance of ALS-systems at a low w/b, e.g. 0.3 and at higher temperatures, e.g. 40-60°C which is realistic to be encountered also in practice. For such conditions a more clear advantage of ALS as a cement substitution may be present. Additionally it would be relevant to investigate the durability properties of ALS substituted systems.