Stability of C-A-S-H in blended cement pastes

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Abstract

The current PhD project is part of a group of four studies on aluminum-substituted calcium silicate hydrate, known as "C-A-S-H". This phase is of interest to study because it is the main phase in pure and blended cements. Most properties of the final hydrated material are conditioned by this phase, however its physical properties and chemical composition are extremely variable. Within a same sample of hydrated cement, the composition may change from one region to another. Changing the cement composition and amount of Supplementary Cementitious Materials (SCMs) greatly reduces the amount of calcium because SCMs provide high amounts of siliceous and aluminous phases to the system. Most publications have shown that C-A-S-H is likely an imperfect form of tobermorite or jennite with many defects and solid solutions, namely silicon replaced with aluminum. As blends are of great interest for economic and ecologic reasons, we therefore need to better understand the phase assemblage and the extent of these solid solutions. We can then increase the accuracy of predictive tools such as thermodynamic modeling which have proven to be very useful provided a consistent database is used.

While one of the four studies focusses on atomistic simulations and the two others synthesize C-A-S-H to characterize the effect of alkali and anions on its composition and structure, the current project deals with the C-A-S-H formed in realistic conditions like those of alite or cement pastes blended with different amounts of metakaolin (a pure silica- and alumina-rich clay) and silica fume (mainly SiO_2), both chosen for their high reactivity. They were cast with water:cement of 0.4 at three temperatures. Three concentrations of KOH were added in samples with alite. Characterization is being done on late hydration times (at least 90 days) by SEM-EDS and TEM-EDS to determine the C-A-S-H composition. TGA and XRD complement these tools to yield more information on the phase assemblage.

The methodology for SEM-EDS and TEM-EDS was investigated. While it remains non trivial to extract useful information from point analyses, appropriate conditions greatly help to yield better quality data which can then be treated to estimate the C-A-S-H composition. First SEM-EDS results from blends with silica fume show an interesting phenomenon regarding reactivity of the SCM and are being investigated for earlier ages. Results from metakaolin are pending in TEM-EDS as the intermixing of the clay with C-A-S-H makes it difficult to analyze in the SEM-EDS.