CHARACTERIZATION AND REDUCTION BY SILICA NANO-ADDITIONS OF THE EFFECTS OF CA-LEACHING IN CEMENT PASTES

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The calcium leaching of the cement hydrated matrix is of vital importance for constructions such as water containers, dams, bridges, etc which have to be in contact with water during their lifetime. This degradation process, despite of being very slow, can greatly reduce the long term performances of the material, ending up on the most severe cases on its complete destruction.

The aim of this work is the study of such a negative phenomena altogether with the effect of the addition of silica nano-particles into the cement paste. For this purpose a coherent set of samples was prepared using ordinary type I Portland cement and a few different commercially available nanoparticle preparations presented in two formats: as an agglomerated dry powder (around 1μm in diameter) and in the form of a colloidal dispersion (particle size smaller than 50nm).

In order to constrain the study to a reasonable time period it was necessary to introduce an accelerated degradation method. The chosen one was pioneered by Carde [1] and consisted of the immersion of the samples into a 6M Amonium Nitrate solution. Having calcium a much higher solubility in this solution than in water means that the dissolution rate is much faster, to the point of being the leaching process for this concentration completely governed by the diffusion rate of the calcium ions. The main advantage of this method is that, apart of its high acceleration rate, the degradation process is of the same nature that the one produced by pure deioniced water.

Several characterization techniques, working at different scales, were used to follow the evolution of the samples as the attack advanced. At the macro-scale the overall sample strength was quantified by the three-point-bending and compression tests while for the micro and nano-scale five more techniques were employed: X-ray diffraction, scanning electron microscopy, EDX-microanalysis, mercury intrusion porosimetry and ^{29}Si MAS NMR. While the four first ones are quite usual on the field of cement and concrete research the last one is less common being, to the best of our knowledge, this the first time that it is used to study the phenomena of calcium leaching.

The main conclusion reached from the subsequent analysis of the results is that silica nano-particles are highly beneficial for the cement paste in two ways. Firstly, evidences obtained through nuclear magnetic resonance show that they modify somehow the C-S-H gel itself making it more resistant to calcium leaching. And secondly, as it is already well known [2], they increase the amount of C-S-H gel by means of a pozzolanic reaction that consumes calcium hydroxide. This last detail is very relevant to this study since portlandite is not only the most susceptible hydration product to be attacked but also the easiest to degrade.

References:

[1] C. Carde, Cement and Concrete Research, **26** (8) (1996) 1257
[2] H.F.W. Taylor, Cement Chemistry (Thomas Telford - Second Edition 1997)