Physico-Chemical Studies of Air Entrainment in Cementitious Systems with and without Fly Ash

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KEYWORDS: air, entrainment, cement, fly, ash, pastes, AEA

ABSTRACT

Very small quantities of surfactants can provide drastic improvements to the freeze thaw resistance of concrete, due to the formation of a highly dispersed network of air fine voids promoted by the surfactant. While the mode of action of these air-entraining surfactants (AEA) can be loosely associated to the formation of air bubbles, the actual mechanism of air entrainment in cementitious systems of varying composition, or by different AEA's, remains largely speculative.

In this paper, the authors describe the development of a protocol to investigate air entrainment in cementitious pastes using commercial or experimental AEA's. Using this protocol, an extensive study was performed on a series of experimental surfactants, selected to help identify the key features of AEA's which are responsible for their respective performances. Three series of homologous surfactants were selected comprising: n-alkylcarboxylates (n-$RCOO^-$), n-alkylsulfonates (n-RSO_3^-) and n-alkylsulfates (n-RSO_4^-). Sodium salts of the latter, with hydrocarbon chain lengths varying between C_7 and C_{12}, were used to investigate the influence of anionic head group and hydrocarbon chain length on the air-entraining performance of these surfactants. Parallel measurements were performed on the solubility of these surfactants in pore solution of cementitious pastes and in related solutions or slurries. The study included three different cements, as well as mixed cement-FA systems. The combined results provide a basis for understanding the mode of action of surfactants in terms of a balance between their inherent surface activity (ability to reduce the surface tension of water) and the solubility of the surfactants in alkaline calcium-containing environments. The paste method was also found most valuable to investigate the influence of FA-carbon on air entrainment, and means to mitigate the carbon effects.

Submitted for consideration in the 2009 World of Coal Ash Conference, May 4-7, 2009.