Fundamental Studies on the Origin and Mitigation of the Effect of Fly Ash-Carbon on Concrete Air Entrainment

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ABSTRACT

The negative impact that fly ash can have on concrete air entrainment is well documented, generally through studies relating air entrainment and the amount of unburned carbon remaining in the FA (LOI). However, important deviations from the air-LOI relationship now force more incisive investigations of the interaction between the surfactants used as air entraining admixtures (AEA) with the FA-carbon, or with other components of fresh concrete. This paper describes the results of an investigation designed to gain further insight into FA-carbon-surfactant interactions, and the way in which these interactions impact on the stability of air voids in cementitious systems. The results of such investigations provide important clues for mitigating the FA-carbon effect on concrete air.

The study involved air entrainment measurements in cement pastes and two foam stability testing protocols. The influence of different forms of powdered carbon and other hydrophobic materials on paste air entrainment and foam stability was determined. As could be expected, an important primary cause for the reduction of paste (or concrete) air content can be attributed to adsorption of the air-entraining surfactants by the various hydrophobic particles. However, it was also found that some materials, although having minimal AEA absorption capacity, had significant negative impact on air entrainment. To elucidate the origin of these observations, the wetting behaviour of the various hydrophobic particles was investigated in the presence of various surface active agents, through contact angle measurements. The latter yields the surface free energy of the hydrophobic particles, and changes in the surface energy by surfactant additives. The results demonstrate that the magnitude of the surface energy plays a key role in the interaction of the particle with surfactant films in foam air bubbles, or at the paste-air interface in cementitious systems. Hence, in addition to AEA adsorption, FA-carbon can dramatically influence concrete air through a disruptive action of the fine hydrophobic particles directly on the surfactant film at the air void interface. The later mechanism should thus be more critical for fly ash containing large amounts of very fine carbon.

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