Features, benefits and challenges of air entrained pavement concrete mixes using fly ash

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ABSTRACT

The benefits of replacing a proportion of cement with fly ash in concrete mixes have been well understood for many years, particularly in the mitigation of alkali silica reactions. In pavement concrete mixes, however, the properties of fly ash can often play havoc in controlling the amount of air in the concrete which is usually required for both protection against freeze/thaw expansive cycles during winter months as well as aiding slipforming processes.

During the burning of coal in power plants, un-burnt fuel is often carried over into the fly ash in the form of activated carbon which can be estimated by measuring the loss on ignition (LOI) of the fly ash. Highly activated carbon particles can lead to the preferential adsorption of molecules of air entraining agents (AEA) that are required to generate air bubbles in the cement paste. Such adsorption leads to a reduction in air content and a subsequent increase in the required dosage of the AEA. If the LOI in the fly ash remained constant, then concrete producers could establish the required dosage of AEA and produce repetitive concrete mixes with consistent air contents – but this is not always the case, as the levels of carbon in deliveries of fly ash vary constantly.

The paper will cover the current means by which some specifications for fly ash limit the permitted coefficient of variation (CV) in LOI as a means of reducing the risk of variable air contents in pavement concrete mixes. Although reasonably effective, this method of specification results in many tens of thousands of tonnes of valuable fly ash that could be used in non-air entrained concrete mixes without issue being discarded annually. Indeed, concrete producers have circumvented this issue by replacing cement with more expensive ground granulated blast furnace slag.

The paper will focus on a novel means by which the presence of activated carbon in fly ash can be “de-activated”, thereby minimising its deleterious effects on the efficiency of AEA’s in air entrained pavement concrete mixes. Short chain fatty acid molecules, when added to the concrete in the form of an admixture, are preferentially adsorbed onto the sites of activated carbon over the molecules of AEA. This results in the AEA being allowed to generate stable bubbles of air, unhindered by elevated, and variable, levels of activated carbon in fly ash.

The paper will also propose that a relaxation in the permitted CV in LOI could allow many thousands of “extra” tonnes of fly ash to be used in both normal and air entrained pavement concrete mixes to replace cement, thereby going someway to alleviate the current shortages of fly ash, particularly in NSW.