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Title: Evaluation of Applicability of Ternary (OPC/FA/SF) Binder Systems for Bridge Deck Concrete

ABSTRACT

The purpose of this research was to examine the applicability of ternary binder systems containing ordinary portland cement (OPC), class C fly ash (FA) and silica fume (SF) for bridge deck concrete. To accomplish this, a series of laboratory and field experiments has been performed. The first part of the work was aimed at examination of the magnitude and source of the synergistic effect in the ternary system incorporating 75% OPC, 20% class C FA and 5% SF. The synergistic effect was observed mainly at later age (no earlier than at 7 days) and was found to be the result of both physical and chemical interactions.

In the second part, a series of in-depth laboratory studies was carried out on four ternary mixtures, each containing either 20% or 30% FA and either 5% or 7% SF subjected to four different curing regimes (air drying, 7 days curing compound application and 3 or 7 days wet burlap curing). In general, all four ternary mixtures exhibited very good transport properties (resistance to chloride-ion penetration, chloride diffusivity and rate of water absorption). However, it was concluded that to ensure adequate strength and satisfactory resistance to salt scaling, freezing and thawing and shrinkage cracking, FA content should not exceed 20%, SF content should not exceed 5% (by total mass of binder) and paste content should be kept below 24% by volume of concrete. Further, wet burlap curing for a minimum of 3 days was required to achieve satisfactory performance and to obtain a reliable assessment of in-situ compressive strength (up to 28 days) using maturity method. It was also determined that ternary concrete does not require “better” air-void system than conventional concrete, as long as the slump is kept below the recommended value of 190 mm.

The last part of this research examined the performance of ternary concrete containing 20% FA and 5% SF in the pilot HPC bridge deck constructed in northern Indiana. Using maturity method developed for the purpose of this study, it was determined that the unexpectedly high RCP values of concrete placed late in the construction season were mostly attributed to low ambient temperature. Additional applications of the developed maturity method were also demonstrated. These include assessment of risk of scaling and reduction in time to corrosion initiation as a function of construction date, as well as estimation of long-term RCP values for concrete subjected to accelerated curing.