ABSTRACT

Verian, Kho Pin, Ph.D., Purdue University, December 2015. Influence of Air-Cooled Blast Furnace Slag (ACBFS) Coarse Aggregate on Properties of Pavement Concrete Exposed to Freezing-Thawing and Wetting-Drying Conditions. Major Professor: Jan Olek.

The main purpose of this research was to evaluate the influence of using air-cooled blast furnace slag (ACBFS) coarse aggregate as a replacement for natural dolomite coarse aggregate in pavement concrete mixtures. All mixtures containing ACBFS were designed to meet the requirements of Indiana Department of Transportation (INDOT) specifications for pavement concrete. The scope of the study included evaluation and analysis of the effects of ACBFS on concrete properties in the presence of three different types of deicers ($CaCl_2$, $MgCl_2$ and NaCl). These evaluations were conducted under simulated temperature cycles that represented exposure to freezing-thawing (FT) and wetting-drying (WD) conditions. A total of eight different concrete mixtures were produced in the course of this study. The mixtures were prepared using two types of coarse aggregates, ACBFS and (for comparison with the typical INDOT mixtures) dolomite. Four different binder systems were used, and included the following: (a) plain - 100% portland cement (PC), two types of binary binder systems (b) 20% fly ash (FA) + 80% PC and (c) 25% slag cement (SC) + 75% PC, and a single ternary system (d) 17% FA + 23% SC + 60% PC.

Each of the mixture produced was used to prepare several types of specimens for laboratory testing. The test performed on fresh concrete included determination of slump, unit weigh and entrained air content. The mechanical properties of the hardened concrete were assessed by conducting compressive strength and flexural strength tests. The durability of concrete was assessed by periodical measurements of relative dynamic modulus of elasticity (RDME) and monitoring the length changes of the prismatic specimens. The changes in the physical appearance of specimens exposed to either FT or WD conditions were documented at different stages of the exposure cycles. The depth of chloride ion penetration was measured after the completion of exposure period. The

combined effects of the deicer/exposure conditions on the microstructure of the concrete were evaluated using scanning electron microscopy (SEM) analysis on the specimens after the completion of the exposure test.

The results from this study revealed that ACBFS is a viable option for coarse aggregate in pavement concrete. The usage of fly ash, slag cement and the combination of both as partial replacement of portland cement was found to not only improve concrete's strength at later age but also to increase concrete durability in the presence of deicers and FT/WD exposure conditions. Among the three types of deicers studied, $CaCl_2$ was found to be the most aggressive in terms of inducing damage to the concrete followed by $MgCl_2$. Thus, it is advised that the use of these deicers on plain concrete pavements should be more strictly monitored and restricted to cases where other deicer can't provide the required safety of the roadway.

Key words: air-cooled blast furnace slag (ACBFS), coarse aggregate, deicers, freezing-thawing (FT), wetting-drying (WD), pavement concrete, durability properties, scanning electron microscopy (SEM), relative dynamic modulus of elasticity (RDME), plain concrete, binary mixtures, ternary mixtures.