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Effect of Finenesses of Fly Ash on Expansion of Mortars in Magnesium Sulfate

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Abstract: This paper presents the effect of fineness of fly ash on expansion of fly ash-cement mortar in magnesium sulfate solution. Fly ash from the Mae Moh power plant in Thailand was classified in to three different levels of fineness of Blaine of 3215, 4440 and 5890 cm^2/g with a median particle size of 25.57, 7.69, and 4.81 microns, respectively. Fly ash at each level of fineness was used to replace Portland cement type I and type V at percentages of 0, 20, 30, and 40 by weight of the cementitious material, to cast mortar bars of 2.5x2.5x30 cm^3. Expansion of the fly ash-cement mortar bars, which were immersed in 5% by weight of magnesium sulfate solution, were measured at the age of 1 to 540 days. The results showed that the replacement of Portland cement type I and type V by fly ash reduced expansion of the mortar bars. When the same level of fineness and same percent of replacement of fly ash were used in the mortar bars, the replacement of Portland cement type V by fly ash produced less expansion than that of Portland cement type I. For the same level of fineness of fly ash, the mortar bars made with 40% fly ash replacement had less expansion than those made with 20 and 30% replacement. The mortar bars with 20-25% replacement of fine fly ash (Blaine fineness of 4440 or 5890 cm^2/g) and the mortar bars with 40% replacement of original fly ash (Blain fineness of 3125 cm^2/g) had the same expansion. The smaller particle size of fly ash not only reduced expansion of the fly ash-mortar bars but also produced higher strength activity index of mortar than the bigger particle size of fly ash. Therefore, very fine fly ash could be used effectively for reducing the expansion and improving sulfate resistance of mortar.

Keywords: Fineness, fly ash, sulfate, expansion, mortar bar.

Introduction

During the last decades, deterioration of concrete by sulfate is frequently observed in concrete structures exposed to high sulfate environment. Sulfate may be found in soils or dissolved in groundwater and is always present in seawater. The concrete structures, especially those constructed underground and under sea water, are at risk of sulfate attack. The majority of the sulfate salts present in ground soil and sea water are sodium sulfate and magnesium sulfate. Sulfate attack of concrete can be classified into two catagories, namely physical and chemical attacks [1]. For the physical attack, the sulfate ions enter the concrete by diffusion, and subsequently react with cement in the concrete, leading to disintegration. For the chemical attack, the sulfate ions react with calcium hydroxide and calcium aluminate hydrate which are components of cement paste, producing solid products with larger volume. Sulfate attack usually exhibits concrete expansion and strength reduction, leading to cracking and spalling.

Many researchers reported the recommendation for improving sulfate resistant in mortar and concrete. Djuric et al[2], Irassar et al[3] and Kurtis et al[4] suggested that low water-cement ratio, low C_3A content in cement, and Portland cement type V could improve the resistance of concrete to sulfate attack. Khatri and Sirivivatnanon[1] concluded that the permeability of concrete and the type of binder played an important role in governing the sulfate resistance. Torii and Kawamura[5] studied sulfuric acid and sulfate resistance of mortar with fly ash and silica fume and found that the replacement of Portland cement by fly ash and silica fume effectively improved the resistance of mortar to sulfuric acid and sulfate attack. Torri et al[6] studied the sulfate resistance of concrete with high fly ash composition and showed that concrete containing fly ash at 50% replacement could improve the resistance against sulfate attack.

In Thailand, it is estimated that fly ash has been produced at the rate of more than 3.5 million tons per year since 2001. However, the utilization of fly ash is