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Long Term Performance of Fly Ash Concrete in Marine Environment

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ABSTRACT

In this study, chloride penetration profile, compressive strength and steel corrosion of fly ash concrete with various covering depths under marine environment were investigated. Control concretes were designed by using Portland cement type I and V with water to binder ratio (W/B) of 0.45. For fly ash concrete, fly ash from Mae Moh power plant in Thailand was used to partly replace Portland cement type I at percentages of 15, 25, 35, and 50% by weight of binder. During casting of concrete cube specimens of 200 mm, steel bars of 12-mm in diameter and 50-mm in length were embedded at coverings of 10, 20, 50, and 75 mm. Subsequently, the hardened concrete specimens were cured in fresh water until the age of 28 days and then were exposed to tidal zone of marine environment in Chonburi province, Thailand. The concrete specimens were tested for chloride penetration profile, corrosion of embedded steel bar, and compressive strength after being exposed to the tidal zone of seawater for 3, 4 and 5 years.

The results showed that fly ash concrete continued to gain strength development up to 5-year exposure in marine environment. The increase of fly ash replacement level in concrete reduced the chloride penetration and corrosion of embedded steel bar. In addition, the embedded steel bar in Portland cement type V concrete had more corroded than that in Portland cement type I concrete.

KEY WORDS: Chloride penetration; Corrosion; Fly ash; Marine environment

1. INTRODUCTION

Marine environment is highly inhospitable for commonly used materials of reinforced concrete structure. The reinforced concrete in marine environment is subjected to various physical and chemical destructions. For chemical action, seawater contains corrosive ions and gases such as chloride and sulfate attack (Broomfield, 1996). However, these mechanisms are combination of many influences of physical damaged, such as hydrostatic pressure, moisture, temperature, impacted force, abrasion-erosion and so on. The actual corrosion of reinforced concrete in marine environment can not be presented completely in laboratory. In addition, the acceptable corrosion state of concrete at long term should be monitored from actual environment. Presently, many researchers have obtained the durability data of marine concrete structure in long term exposure (Troconis de Rincon, Castro, Moreno, Torres-Acosta, Moron de Bravo, Arrieta, Garcia, Garcia, and Martinez-Madrid, 2004; Dehwah, Maslehuddin and Austin, 2002; Thomas and Matthews, 2004). However, a few researches have studied on the corrosion of fly ash concrete relating to various covering depths of concrete, compressive strength, corrosion of steel, and chloride penetration profile. Throughout, it has not been found the long term durable data of concrete in marine environment of South East Asia which is in a hot and high humidity climate. Thus, the objectives of this research are to study the effect of fly ash on the compressive strength, chloride penetration profile, and steel corrosion of concrete with various covering depths under marine environment up to 5-year exposure.

2. EXPERIMENTAL PROGRAM

2.1 Materials

Portland cement type I and V, fly ash obtained from Mae Moh power plant in Thailand, graded sand and crushed limes stone with maximum size of 19 mm were used in this study. Fly ash, Portland cement type I and V have the median particle size of 30.6, 25.0 and 19.2 μm, respectively. For the chemical compositions, the sums of SiO_2, Al_2O_3, and Fe_2O_3 in fly ash was 79.45% indicating the class F fly ash in accordance with ASTM C 618. In additional, Portland cement type I and V had C_3A content of 9.23 and 1.80%, respectively.

2.2 Specimens and tested program

In this study, fly ash concretes were cast by using fly ash from Mae Moh power plant to replace Portland cement type I at percentages of 15, 25, 35, and 50 by weight of binder. W/B was kept constant of 0.45. Control concretes were designed by using of Portland cement type I and V. The 200-mm concrete cube specimens were cast and steel bars (12-mm in diameter and 50-mm in length) were put in the concrete. The steel bars were embedded with concrete covering depths of 10, 20, 50 and 75 mm. All mix proportions are shown in Table 1. The concrete specimens were demoulded after one day of casting and then cured in water for 27 days. Compressive strengths of concretes were determined