The 2016 World Congress on
The 2016 Structures Congress (Structures16)
Jeju Island, Korea, August 28-September 1, 2016

Evaluation of Durability of Low Heat Cement-Based Ternary Blended Concrete

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ABSTRACT

The purpose of the present study is to evaluate the durability of ternary blended low heat concrete applied with low heat cement, granular fly ash, and lime stone powder. To this end, experiments were conducted on the resistance to chloride ion penetration, carbonation, and freezing and thawing, and sulfate resistance of ternary blended concrete. And the results of the experiment were compared with the control specimen (ordinary Portland cement 80%+ fly ash 20%). The targeted 28-day strength of concrete was selected to be 42 MPa and the concrete mixes were cured under the isothermal conditions of 5℃, 20℃, and 40℃. All concrete specimens showed low values not exceeding 1000 Coulomb ("very low" grade) in experiments on the resistance to chloride ion penetration and satisfied the standard 90% or higher durability factors in experiments on the resistance to chloride ion penetration. Ternary blended concrete mixes were evaluated to have approximately 40% lower resistance compared to the control specimens at 12 weeks in the experiments on the resistance to carbonation and carbonation depths generally increased along with increases in curing temperatures for most concrete specimens. All test specimens showed similar changes in appearances at 28 days and 91 days of immersion periods on sulfate resistance, however, the low heat concrete mixes showed higher residual compressive strength ratios according to immersion periods compared to the control specimens. According to the results of experiments on durability, ternary blended concrete mixes showed equal or higher performances compared to the control specimens.

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Note: Paper to be submitted to "Computers and Concrete, An International Journal" for the purpose of Special Issue.

1. INTRODUCTION

As concrete structures become bigger, mass concrete structures such as high-rise buildings, bridges, and dams are damaged by cracks caused by the heat of hydration. Cracks caused by the heat of hydration may decrease the resistance of concrete to withstand the design load or reduce durability of structures. Besides cracks caused by the heat of hydration, there are various factors that degrade the structure which in turn decrease the durability of mass concrete. Such factors that decrease structure durability may be classified as physical factors and chemical factors. The physical factors include damage (abrasion and cracks) and impairments caused by freezing, and the chemical factors include corrosion of concrete and steel reinforcing bars. Since most of the deterioration factors are caused by the penetration and diffusion of hazardous substances from the outside of the concrete, it is important to prevent the penetration of deterioration factors by densifying and compacting concrete. (CEB-FIB 2009) Generally, binary or ternary concrete is used to prevent the generation of cracks caused by the heat of hydration in mass concrete, whereas binary or ternary concrete is manufactured by mixing a certain amount of admixture from industrial byproducts such as fly ash and blast furnace slag. Studies have been actively conducted on the mechanical properties and the heat of hydration of binary and ternary concrete. (Hwang et al. 1991, Schutter et al. 1995) However, insufficient studies about durability against deterioration factors have been carried out.
In the present study, experiments were conducted on the resistance to chloride ion penetration, carbonation, freezing and thawing, and sulfate penetration to evaluate the durability of heat cement-based ternary blended concrete which was developed to reduce the heat of hydration of mass concrete. (Kim et al. 2016) The experimental results were compared with those of ordinary Portland cement (OPC)-based concrete.

2. Concrete Material Properties

The design reference strength of the concrete used in the durability evaluation was 42 MPa. The ternary concrete was prepared by mixing low heat Portland cement (LHC), granular fly ash (GFA), and limestone powder (LP), and the water-to-binder ratio (W/B) was determined as the mixing variable, considering the freezing winter (5℃), standard period (20℃), and scorching summer (40℃) environment. The control mixture was prepared by mixing OPC 80% and FA 20%. Table 1 shows the concrete mixing design applied to the experiments. The fineness of OPC and LHC was 3400 cm2/g, and the fineness of FA, GFA, and LP was 3,400 cm2/g, 4,500 cm2/g, and 3,420 cm2/g, respectively. The mixing variable, W/B, was determined as 27.5%, 30%, and 32.5% for the freezing winter, standard period, and scorching summer, respectively.

3. Concrete Durability Experiment

3.1 Resistance to chloride ion penetration

The experimental results of the resistance of ternary blend concrete to chloride