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Technical Report

Effects of thermal and mechanical activation methods on compressive strength of ordinary Portland cement–slag mortar

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ABSTRACT

Activation methods and curing regimes have crucial effects on the strength of mortars and concretes. The objective of this investigation is to examine the early and later compressive strength of activated ordinary Portland cement (OPC)–ground granulated blast-furnace slag (GGBFS) mortars and identify the most effective activation technique. The methods of activation used were thermal, mechanical and thermal–mechanical combined. Two curing regimes were adopted and five groups of mortars were prepared. It was observed that OPC–GGBFS mortars have greater sensitivity to OPC mortars against the curing regimes. However, the study revealed that there was no particular activation method which when used gave the best results for both early and later strengths and did not cause strength loss. It also proved that the most effective activation method for early strength is a combination of both the thermal and mechanical, while for later strengths, none of the activation methods was recommended.

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1. Introduction

Generally, the cement–slag mortars can be divided into three groups as: ordinary Portland cement (OPC) mortars (OMs), Ordinary Portland cement–slag mortars (OSMs), and slag mortars (SMs). Based on other researches, it can be said that among the activation methods, Chemical (C), Thermal (T), and Mechanical (M) are the most usual activation methods. However, for activation of the OSMs, the combinational methods of activation such as Chemical–Thermal (CT), Chemical–Mechanical (CM), Thermal–Mechanical (TM), and Chemical–Thermal–Mechanical (CTM) can be used. It is well known that for the mortars with cement particles like OMs and OSMs, the use of activation methods, including activators, are not effective [1,2], and then in this research work, only T, M, and TM methods were used. Not much research has been reported on the combinational activation methods of OSMs. The addition of alkalis to Portland cement results in a reduction of strength after 3 or 7 days, because hydration chemistry and the morphology of the hydration products are changed due to the presence of alkalis. OPC/slag mixes activated by alkalis showed a lower strength than the slag alone activated by an alkali [3].

Generally, it can be said that the SMs have both a low early and then ultimate strengths. The OMs have high early strengths and also relatively high ultimate strengths. Finally, the OSMs have low early and high ultimate strengths. However, some activation methods can be used to improve the strengths at early ages. Based on the results reported by other researches [4,5], it has been observed that by using chemical activators, early strength of the SMs can be improved.

Chemical activation refers to the use of some chemical substances to activate the potential reactivity of cementitious components. Some chemical activators are Na_2SiO_3, NaOH, KOH, and Na_2CO_3 [6]. The activator(s) can be added during the milling of cement/slag or can be dissolved in the mixing water and added during the mixing of cement/slag pastes, mortars, and concrete. The technology is very simple and does not need extra equipment.

Raising temperature is more helpful to the reaction processes for higher reaction activation energies than those with lower reaction activation energies. Many researches [7] have shown that Portland-cement slag has higher hydration activation energy than Portland cement and the higher the replacement of cement with slag, the higher the apparent hydration activation energy. Under normal conditions, blast-furnace slags show a higher reactivity with lime than other glassy pozzolans. Hardened cement pastes and concretes can reach their maximum strength within several hours through elevated temperature curing. However, the ultimate strength of hardened cement pastes and concretes has been shown to decrease with curing temperature. Other researchers have indicated that slag was more sensitive to heat than Portland cement due to its high apparent activation energy [8,9]. Roy and Idorn [8] even suggested that the combined effect of alkalis and heat may be synergetic during early hydration.

Heat curing is commonly used in the production of precast concrete elements to increase the rate of hydration and accelerate early age strength development. High elevated temperatures

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