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Effects of steam curing on strength and porous structure of concrete with low water/binder ratio

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ABSTRACT

A research program was carried out to investigate the effects of duration of initial steam curing at atmosphere pressure on compressive strength of concrete with low water/binder ratio. The results showed that the compressive strength of samples steam cured for 5, 10, 14 h increased, while it decreased distinctively for sample steam cured for 24 h. Mercury intrusion porosimetry (MIP) method and scanning electron microscope-backscattered electron (SEM-BSE) image analysis technique were adopted to measure the corresponding variation of porous characteristics caused by the increasing duration of steam curing. The changes in coarse porosity and total porosity calculated by SEM-BSE image analysis and MIP method respectively could indicate the relationship between porosity and mechanical properties of the concrete subjected to different duration of steam curing. Compared with total porosity obtained by MIP method, the coarse porosity by SEM-BSE image analysis was in better accord with the compressive strength because the coarse pores measured by SEM-BSE image analysis were larger than 0.5 μm and included not only the interconnected pores but also the closed ones. An empirical model was developed to evaluate the influence of duration of initial steam curing on the compressive strength of concrete. By comparison, the measured compressive strength was in great accordance with the compressive strength calculated by the proposed model.

1. Introduction

In the case of concrete with low water–binder ratio and high mineral admixture replacement, strength changes are more complex in nature due to the combined physiochemical effects of pozzolans in concrete. The physical influence is the refinement or coarseness of pore structures while the chemical phase consists of pozzolanic reactions and hydration process [1]. As known from existing studies of concrete behavior, there is a number of well-established strength versus porosity relationships [2]. It has to be pointed out, however, that such expressions only consider the effects of porosity on strength. In fact, the pore size distribution is another major parameter influencing the strength of concrete [3]. But it was noting that few studies are on the quantitative effects of different pores on the strength of concrete.

Currently, initial steam curing at atmosphere pressure is increasingly used in precast concrete elements, for example, precast tunnel segment, in order to speed up the production efficiency. The typical parameters of this steam curing process are precuring time, maximum steam temperature and duration at the maximum temperature [4]. It is confirmed that the steam curing at low pressure could improve the quality of high performance concrete incorporating mineral admixtures, comparing with standard curing [5]. It was reported that the optimum maximum temperature of steam curing was near 60 °C considering strength and the increase of precuring time increased the strength of concrete [6]. However, there are few studies emphasizing the effects of duration of initial steam curing at the maximum temperature on the strength of high performance concrete.

In this paper, firstly, the effects of duration of steam curing at 50 °C on strength were investigated. Then the changes of porous characteristics were evaluated by MIP method and SEM-BSE image analysis technique. This was followed by an appraisal of the contributing coefficients of different pores on the compressive strength of high performance concrete. Finally a new empirical model was proposed to express the influence of pore size distribution on compressive strength and the effects of duration of initial steam curing on the compressive strength could also be analyzed by the proposed model.

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