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Effect of copper slag on the self-compacting concrete properties

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Abstract

This experimental study investigates the effects of substitution of cement with copper slag in self-compacting concrete (SCC) mixtures. The rheological and mechanical properties of SCC have been investigated. Six concrete mixtures were prepared with different proportions of copper slag ranging from 0% (for the control mix) to 50%. Ordinary Portland Cement (OPC) was partially replaced by different percentages of copper slag (0, 10, 20, 30, 40 and 50%). The workability of fresh SCC was measured using slump test, V-funnel flow time test, J-Ring and L-Box tests. Compressive strength was determined at the ages of 3, 7, 14 and 28 days. Compressive strength of SCC decreased with the increasing in copper slag content.

Keywords: SCC, Copper slag, Cement, Rheology, Strength.

1. INTRODUCTION

SCC has been considered as a great development in construction field since its first use in Japan. Its introduction represents a major technological advance which led to a better quality of concrete, increased productivity and improved working environment on site [1]. The high fluidity is the main property of SCC so that it can be placed under its self-weight without vibration. In order to obtain a SCC of high flow-ability without segregation or bleeding during the transportation or placing, the use of high powder content, superplasticiser and viscosity modifying admixtures seems a good solution. However, the cost of such concrete is significantly high [2]. The use of mineral additives such as silica fumes (SFs), fly ash (FA) and slags could reduce material cost and enhance the self-compatibility [3].

Thus, the use of supplementary cementing materials have become an integral part of Portland cement concrete production, and the research on new materials with supplementary cementing potential, including waste or recycled materials (for example, fine glass powder) is receiving considerable attention from the scientific community.

Recently nanotechnology is being used or considered for use in many applications and it has received increasing attention also in building materials, with potential advantages and drawbacks being underlined [4,5]. In this field, a new pozzolanic material, produced in copper mineral kilns, was introduced into the market. Due to the micro-scale size of particles, copper slag potentially could be more effective than condensed silica fume, but less than cement.

Until now, copper slag have been widely used for abrasive tools, roofing granules, cutting tools, abrasive, tiles, glass, road-base construction, railroad ballast, asphalt pavements. The effect of copper slag as a partial substitute for ordinary Portland cement on the hydration reactions and its role as a pozzolanic material have been reported in different works [6,7]. Several researchers have investigated the possible use of copper slag as fine and coarse aggregates in normal concrete and its effects on the different mechanical and long-term properties of mortar and concrete. Despite some benefits of using copper slag as fine and coarse aggregates, some negative effects have been reported in these works such as delaying the setting time specially when only copper slag has been used as fine aggregate. Ayano and Sakata [8] reported that the slag component was on insoluble residue in the 0.15 mm size that could be readily removed by washing. They concluded that the effect of copper slag on the setting time was different with the particle size of copper slag (that is, the smaller size of copper slag causes the longer delay in the setting time). However, the effect of copper slag on the setting time was decreased by increasing the washing times. Shoya et al. [9] reported that the amount and rate of bleeding are increased by using copper slag fine aggregate depending on the water to cement ratio, the volume fraction of slag and air content. They recommended using less than 40% of copper