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Waste press mud in enhancing the performance of glass powder blended cement

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ABSTRACT

Due to the significant environmental damages caused by cement production, the use of blended cement has gained greater attention. This paper explores the novel use of solid waste from the sugar industry namely press mud (PM) and waste glass powder (GP) as cement replacement in ternary blended cement. The ternary blended cement consists of 20% GP and the influence of PM at various cement replacement levels between 5 and 20% was investigated. The fresh, strength, sorption, morphological, and thermogravimetric characteristics of the ternary blended cements were evaluated. The results showed that the incorporation of 10% and 15% of PM could improve the consistency, early and later age strengths, exhibit similar flexural strength and reduce the sorptivity of the GP binary cement mortar. The morphologies were also observed to have improved by reducing of voids, facilitating reaction of GP particles, and contributing additional hydration products. This was confirmed by thermogravimetric analysis results, whereby more hydration products were found in cement-GP-PM ternary cement pastes. In overall, the suitable integration of PM could improve the properties of ternary blended cement containing GP while reducing the usage of cement.

1. Introduction

The environmental impact from cement production is one of the most pressing issues globally. It was reported that around 0.9 kg carbon dioxide (CO_2) is emitted for every kg production of ordinary Portland cement having more than 90% clinker to cement ratio [1]. With around 4 billion tons/year cement production globally [2], this translates to around 500 kg/CO_2 per capita being produced every year. Hence, this has motivated researchers to explore alternative cements with lower environmental impact. Several attempts have been made to study the feasibility of incorporating by-products as supplementary cementitious material (SCM) to partially or fully replace cement in concrete [1,3,4]. These by-products can originate from different industries or agriculture activity and mostly disposed as waste [5]. Nowadays, the cement industry is moving towards sustainable blended cements with SCMs, and this has been effective in reducing CO_2 emissions with an average of cement replacement level above 35% [6]. According to International Energy Agency roadmap [7], the current clinker to cement ratio could be reduced from 0.65 in 2014 to about 0.60 in 2050 by introducing SCMs to replace cement. As a result, cement emission could be decreased by up to 300 kg/CO_2 per capita per year.

Glass powder (GP) is one of the more commonly investigated SCMs as the GP mainly consists of amorphous silica, which allows it to exhibit good pozzolanic ability [8]. The pozzolanic reactivity of GP in the blended cement is due to the reaction between amorphous silica compounds (mainly SiO_2) in the GP with the calcium hydroxide (CH) produced from cement hydration reactions [9]. However, the pozzolanic reaction of GP is likely to occur after 7 days as SiO_2 decomposition requires an alkaline environment which is available after cement has started to react [10]. This limits the use of GP in cement mixture to attain good early age strength. Most literature found that beyond 20–30% replacement level, the performance of GP binary cement mixture began to decline. Nevertheless, in overall, the use of adequate amount and fineness of GP in the cement mixtures can improve the rheological performance [11], long-term mechanical performance [12], durability performance [13], and reduces the environmental impact

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