Strength and Microstructural Properties of Mortar containing Soluble Silica from Sugarcane Bagasse Ash

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Abstract. Sugarcane bagasse is among the abundantly available waste in agriculture industry. The proportion of siliceous ashes after the incineration process is one of the attractive features in sugarcane bagasse. However, its low bulk density would result in an additional issue for further use as cement replacement material, since higher replacement volume will bring more hydrophilic particles of sugarcane bagasse ash into the mixture. Therefore this research aims to extract the reactive silica from sugarcane bagasse ash and increase its bulk density by converting it into soluble form. The process was divided into three stages, which were pre-treatment and incineration of sugarcane bagasse, conversion into soluble form, and production of mortar specimen. Soluble silica from sugarcane bagasse ash was used to partially replace cement content in mortar, hence its effect on the hydration process can be evaluated. Compression test and scanning electron microscope analysis were performed to observe its effect on the strength and microstructural development of mortar framework. The results show that the inclusion of soluble silica would enhance the early hydration rate and improve the consolidation of cement matrix via additional calcium silicate hydrate formation, which would increase the capability of internal mortar framework to distribute loads and achieve higher strength.

Introduction

Utilization of industrial and agricultural wastes are considered to be an important step in protecting the environment via reduction of non-renewable resources consumption [1-3]. Reactive ashes from fibrous agricultural waste products have been known for its ability to improve the performance of composite binders and concrete. Sugarcane bagasse ash (SCBA) is one of the common agricultural waste products with high pozzolanic reactivity and micro-aggregate filling effects [4-7]. The high pozzolanic reactivity of SCBA is attributed to the amorphous white ash silicon dioxide and its small cellular particle size [8, 9]. With the particle size smaller than Portland cement, it is able to increase the packing density of hardened composite paste and enhance the micro and macro properties of concrete [10-12].

However, the bulk density of SCBA after chemical pre-treatment and burning process is extremely low, making it problematic to increase the volume of cement replacement without resulting in high water engrossment due to the over-dominance of ash volume in cementitious system [13]. The excessive amount of ash with high surface area due to micro voids formation in its cellular structure will lead to higher free water absorption and decrease the strength of hardened cementitious framework.

Former researchers have investigated the production of siliceous gel from rice husk and geothermal sludge to produce cementitious material with better microstructure and thermal performances [14-16]. The effects of siliceous gel in cementitious material are significantly influenced by nano-metric sized particles that are responsible in modifying the liquid phase viscosity and its pozzolanic properties [14, 15, 17]. Therefore this study was performed to study the conversion of SCBA into soluble silica, hence the use of SCBA based pozzolan as prospective cement replacement material can be optimized.