EARLY-AGE PROPERTIES OF SORGHUM HUSK ASH AND CALCIUM CARBIDE WASTE BINDER IN MORTAR

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Portland cement (PC) is a binder that is most commonly used as construction material in the production of mortar in masonry and concrete. The manufacturing process of PC during clicker production is however noted to contribute to CO2 emission which makes it a non-eco-friendly material. Notwithstanding, reports on total replacement of PC are scarce in literature. Sorghum husk ash (SHA), which is an incinerated ash from agricultural by-product consisting majorly of amorphous silica (SiO2), when combined with calcium carbide waste (CCW) an industrial by-product generated from an acetylene gas production process with major component of lime (CaO) in the presence of water forms compounds possessing cementitious properties. This paper reports on the early-age properties of SHA (as SiO2 source) and CCW (as CaO source) binder in mortar. Paste from different binder combinations of SHA/CCW were studied for setting time while the mortar samples were used to study the rate of hydration and strength development. The study revealed the SHA sample to be of high SiO2 (84%) and CCW is majorly CaO (66% content). The results obtained showed improvement in the performance of binders with superplasticizer formulated from 70/30, 60/40 and 50/50 SHA/CCW respectively, having 28days compressive strength of 7.6 N/mm2 [MPa], 7.0 N/mm2[MPa] and 5.7N/mm2[MPa] representing 36%, 34% and 28% of cement type I (CEM I) strength. The study showed that addition of superplasticizer reduced the water demand and improved the rate of hydration. The binder combinations of 70/30, 60/40 and 50/50 SHA/CCW with water-reducing admixture can be adopted for use in masonry works as it conforms to type N of ASTM C270 mortar.

Keywords: Binder; Calcium carbide waste (CCW); Mortar; Sorghum husk ash (SHA); Superplasticizer.

INTRODUCTION

The process of concrete and mortar production uses Portland Cement (PC) as binder for strength development and other desired properties and this has been noted to be the prominent global practice (Mehta and Monteiro, 2014). The manufacturing process of PC is however noted to contribute around 5% of global CO_2 emission resulting from clinker production and the fossil fuel used for pyro-processing (Rubenstein, 2012). Clinker production involves heating calcium carbonate ($CaCO_3$) in the kiln at temperatures of above 900°C resulting in lime (CaO) and CO_2 as shown in equation 1.

$$CaCO_3 \xrightarrow{heat\ (>900\ oC)} CaO + CO_2 \qquad (1)$$

The quick lime CaO is further made to react with materials containing silica (SiO_2), alumina (Al_2O_3) and iron (Fe_2O_3) at higher temperatures of about 1450°C. This is then removed from the kiln, allowed to cool, ground to fine powder and mixed with about 5% gypsum to control the setting process (Neville, 2012; Mehta and Monteiro, 2014). The major components of PC is stated as CaO, SiO_2, Al_2O_3 and Fe_2O_3 with strength determinant being the CaO in combination with SiO_2 which forms hydrated lime – $Ca(OH)_2$ in the presence of water resulting in formation of CaO-SiO_2-H_2O – Calcium Silicate Hydrate (C-S-H) which is the final product for strength development as cement hydration progresses after water contact.

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