Pristine Amorphous Silica Xerogel inclusion in Limestone Calcined Clay Cement (LC3) production

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With the ever-dwindling reserves of natural resources and the desire for sustainable and responsible green alternatives, the construction industry is no exception to this new normal. Supplementary Cementitious Materials (SCMs) have been successfully utilized to augment cement formulation without compromising its overall performance while reducing the net carbon footprint. Unfortunately, certain SCMs, such as fly ash, will be unavailable in some geographical regions due to the closure of traditional coal-powered plants for healthier green energy [1]. This study explored the incorporation of a sol-gel method-derived pristine amorphous silica xerogel produced from rice husk in the production of Limestone Calcined Clay Cement (LC3). Powder X-ray diffraction (PXRD), X-ray fluorescence (XRF), and Scanning Electron Microscopy with Energy Dispersive X-ray detector (SEM-EDX) were used to characterise the mineralogical and chemical composition of silica xerogel produced, clay, and calcined (800°C for 2 hours) clay samples. The cement formulations were then prepared by blending clinker, calcined clay (10%, 20% and 30%), limestone, amorphous silica xerogel (2%), and gypsum. Standard laboratory tests conducted included residue retention on sieve, loss on ignition, compressive strength, water consistency, and insoluble residue. A characteristic amorphous silica hump around 22° two theta with trace crystalline halide contamination was identified. The SiO2 + Al2O3 + Fe2O3 content in the clay deposits was over 85%, guaranteeing their pozzolan active nature with similar diffractograms having quartz and albite as the major phases and muscovite and microcline being the minor phases present. Successful calcination of the clay samples was confirmed by the disappearance of the distinct kaolinite peak around 12° two theta. The control sample recorded a percentage LOI of 11.58% whiles the 10%, 20%, and 30% LC3 samples scored 9.07%, 8.10%, and 7.90%, respectively. The retention of residue results was all within the 10.00 ± 2.10% target. The 7-day early compressive strength test of the samples was lower than <4.0MPa of the 38.40MPa recorded for the control. Formation of calcium silicate hydrates (C-S-H) derived from alite (C3S) and belite (C2S) and secondary C-S-H derived from SCMs influenced the compressive strength properties [2]. Additionally, a strong positive correlation was observed between water demand and the concomitant increase in the insoluble residue fraction of the LC3 formulation as the calcined clay content increased. The intricate combination of the large surface area, fine particle size, and chemical contribution of the pozzolanic reactions of the multiple phases of the cement contributes to its overall performance. This study illustrates that the creative and innovative solutions to the looming crisis of resource unavailability by the production of low-carbon-based cement incorporating plant-based biomass is a viable option for SCMs, valorising rice husk ordinarily considered as waste for economic and environmental advantages.

References

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