Developing a New Alkaline-Activated Cement Based on Carbonation Process to Reduce CO2 Emissions

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Cement production contributes approximately 8% to global CO_2 emissions. Researchers are exploring alternatives such as alkaline-activated cement (AACs), that utilize industrial by-products like ground granulated blast furnace slag and cement kiln dust (CKD). However, challenges arise from freshwater usage and the costly, toxic nature of alkaline solutions. Carbonation has emerged as a potential alternative, utilizing CO_2 to cure cement instead of water. This study proposes a novel AAC product by combining Slag and CKD, employing carbonation, and incorporating biochar, lime, and Carbon nanotubes (CNTs) to enhance the process. The aim is developing a sustainable cement mixture and improving CO_2 absorption and strength. The methodology involved mixing slag and CKD with water in a ratio of 0.45. The experiments encompassed variations in slag and CKD ratio, atmosphere and CO_2 curing, and the addition of biochar and lime. Two batches, "S60+CKD40" and "S40+CKD60," exhibited the highest strength. They were further characterized for physicochemical properties. FT-IR revealed the presence of C=O bonds (calcite) formed from CO_2 and O-H bond (portlandite) reactions. XRD confirmed the presence of calcite and quartz. TGA demonstrated that the CO_2 uptake percentage doubled after adding biochar, also showed the formation of C-S-H (calcium silicate hydrate), indicating a stable cementitious phase. Samples containing CNTs exhibited the best mechanical performance (17.5 MPa), showing formation of higher carbonate phases, and after adding lime, the strength was enhanced by 51%. In conclusion, carbonation showed potential in fabricating AACs. This research contributes to sustainable cement production and CO_2 sequestration in building materials.