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Investigation of Physical-Mechanical Characteristics of Granulated Artificial Aggregates Synthesized from Wood Ash Using Green Technology

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Abstract : Different ecological binders have been used to minimize the negative effects of cement production and use on the environment. Wood ash is one of these alternative binders, and there has been increasing research related to this topic recently. The incineration process in power plants produces numerous amounts of residues, the potential applications of which remain incompletely understood. However, it is established that wood ash improves concrete properties, serves as a fertilizer, and substitutes natural aggregates in artificial aggregate production. This study presents the production and properties of wood ash artificial aggregate, their integration into concrete, and the assessment of their strength. Due to the aforementioned large amount of incineration waste accumulating in landfills, the recovery of this waste is important, and reuse and recycling of this waste is necessary. Artificial aggregates stand out as a significant innovation in this effort. In this study, the artificial aggregate was carbonized using wood waste incineration ash and alkali activators, with the alkaline activator consisting of Ca(OH)2. Various mixtures were formulated, incorporating different materials and compositions of activators. Initially, fillers were created using wood ash, followed by formulations subsequently supplemented with wood ash. A series of tests, including XRD, SEM, and compression tests, were conducted. The artificial aggregate exhibits minimal water absorption and holds potential as a substitute for natural materials. Its prospective applications extend to agriculture, where it could function as a fertilizer, and construction, where it could serve as an artificial aggregate. Concrete incorporating the artificial aggregate demonstrates stability, stiffness, and relatively low density. In our research, a test was developed and applied to determine the compressive strength of a manufactured artificial aggregate, not by direct loading, but by subjecting a cementitious test specimen containing the aggregate under test to a load. In this way, the test not only determines the effect of the aggregate on the compressive behavior of such a specimen but also the characteristics of the fracture, which shows how these artificial aggregates adhere to the cement matrix. This testing methodology holds promise for evaluating the suitability of artificial aggregates in construction materials, not only in terms of their load-bearing capacity but also of their adhesion to the mineral binder. The results showed that the mechanical properties of granular artificial aggregates vary significantly with the amount of binder (lime), i.e. an increase of ~15% in the amount of binder resulted in an increase in the crushing strength of the carbonized aggregate by ~15-20%, while the compressive strength of the cementitious specimen with this aggregate increased by ~18%.

Keywords : wood ash, artificial aggregate, carbonization, compressive strength
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