Alkali-activated materials and Geopolymers from wastes and secondary raw materials: innovative and sustainable building products

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Doctoral Thesis Abstract:

The worldwide population growth expected in the coming years will lead to an increase in housing needs and therefore a demand for building materials. This demand cannot be fully satisfied using of virgin materials that are increasingly expensive from the point of view of environmental sustainability. The circular economy and therefore the reuse and recycling of secondary raw materials and wastes is the solution. Thanks to the addition of an alkaline reagent to a pre-treated waste it is possible to produce an alternative binder that can be used to create more sustainable building products, thereby promoting circularity processes in the construction and infrastructure sectors and enhancing compliance with Green Public Procurement. Alkali-activated materials and Geopolymers despite differences at chemical level and of final results, both represent a possibility to create an entirely new market of products.

The current virgin materials cannot be replaced by a single new resource, this is why it is necessary to study as many wastes and second raw materials as possible with similar characteristics that can be part of a new production chain. In this research will be presented the characterization and the experimental campaign carried out on two secondary raw materials, quarry scraps and volcanic ashes; two wastes, stone sawing sludges and dredging sludges from sediments of hydroelectric reservoirs basins.

Quarry scraps have a high cost of storage or disposal and although they are already used in other sectors the demand for these materials is low, local producers in Baveno has invited the research group of the Politecnico di Torino to find another way to reuse this powder.

The volcanic ashes produced by Mount Etna causing enormous costs for Sicilian society. In 2021 it lost at the legislative level the qualification of waste that causes problems in the management of this resource.

Sawing sludges (coded EER 01 14 13) were the wastes that underway the research line on AAMs and Geopolymers at Politecnico di Torino on the push of various stone producers in Piedmont. This research led to the registration of an international patent (WO 2017/056122 A1) and created the basis for this research.

Sediments and dredging sludge (coded EER 17 05 06) in general represent a problem of global significance. Those originating from (natural or artificial) water reservoirs designed to store water both as a reserve and to produce electricity. Climate change, whose effects include drought and extreme flooding, is increasingly driving the development of new water infrastructures that are also beneficial to produce additional renewable electricity and aid in the transition away from fossil fuels. Over time, the volume of sediments deposited on the seafloor of the basins increases, indicating a percentage of reservoir burial. Once removed, the dredging sludge from reservoirs is managed primarily through either downstream reflux, long-term storage, or landfilling, these non-solutions entail enormous economic, social, and environmental costs.

To conclude this research led to the creation of several laboratory-scale building prototypes for which not only were dedicated recipes developed, but also low-cost implementations in existing industrial processes were studied to facilitate the industrial scale-up.