LIFE CYCLE ASSESSMENT OF ALKALI ACTIVATED CEMENT COMPARED TO ORDINARY PORTLAND CEMENT

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Approximately 8% of the global emissions of CO_2 are originated by the cement industry, which consumes on average between 4 to 6 GJ per ton of cement. Ordinary Portland Cement (OPC) is the most used cement for construction purposes. Every year, around 4 billion tonnes (Gt) of OPC are manufactured. For each kg of OPC produced, 0.81 kg of CO_2 is generated. Therefore, seeking cements with more environmentally friendly manufacturing process, economically viable, and socially relevant is necessary. One of the most promising materials are the Alkali-Activated Cements (AAC), where its components are an aluminosilicate precursor and alkaline activators. The precursor used in this study is Weathered Bottom Ash (WBA), a waste obtained from the Municipal Solid Waste Incineration (MSWI). On the other hand, the alkaline activators are sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3). The name of the AAC developed is Sustainable-AAC (Sust-AAC).

This project is focused on searching for new materials that could reduce the use of OPC as a building material. To be able to assess the associated environmental impacts, a comparison between AAC and OPC (CEM I) through a Life Cycle Assessment (LCA) following the standards ISO 14040:2006 and ISO 14044:2006 is performed. The LCA methodology allows identification and quantification of relevant inputs and outputs of the system, thus, evaluating the potential environmental impacts associated. The system boundary of this project is cradle-to-gate and the functional unit of the assessment is 1 ton of commercial cement. The OPC inventory is carried out through the values obtained in GaBi Software and the Sust-AAC inventory is made from the previous studies performed in the DIOPMA research group, on a laboratory scale.

The results show that the OPC has higher impact on global warming, energy consumption, water consumption, and mineral extraction categories compared to Sust-AAC. In OPC manufacturing, the kiln stage is the most energy intensive stage (by the chemical reaction and by the fossil fuel requirement) and therefore, has the most significant environmental impact in terms of CO_2 emissions and energy consumption. In contrast, the highest environmental impacts on the Sust-AAC are due to the production of Na_2SiO_3. The main reason for the energy-saving is because Sust-AAC production does not need a kiln with high temperatures. In addition, the use of waste as raw material promotes a circular economy and, at the same time, reduces the extraction of natural resources. Then, the environmental performance in the Sust-AAC is promising compared to OPC. Sust-AAC is suitable to be used as lightweight material and as insulation material for thermal insulating applications. This application can contribute to realising operational energy savings and performance benefits.