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Advancements in Sustainable Construction: Leveraging Mining Waste for Eco-Friendly Building Solutions

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Extended Abstract

A growing number of severe and frequent heat waves, storms, bushfires, rising sea levels, melting glaciers, and warmer oceans are all consequences of global warming, which has been brought on by a large increase in greenhouse gas (GHG) emissions in recent years. Among the primary greenhouse gases (GHGs) having the most worrisomely detrimental effects on the environment is carbon dioxide (CO_2). Over the past ten years, considerable weather variations have been caused by CO_2 emissions from the manufacture of cement. Since concrete is the second most consumed substance worldwide after water, the demand for it has consequently skyrocketed.

According to the statistical information, the total quantity of cement production worldwide amounted to an estimated 4.1 billion tons in 2022, pointing to a significant increment over the past three decades. In 1995, the production amount stood at approximately 1.39 billion tons, making it evident that within these 27 years, it has escalated by three times [1]. Regrettably, this rapid growth of cement production has led to adverse impacts on the environment with the emissions of CO_2. As reported by International Energy Agency, the annual global CO_2 emissions from the construction industry were 13% in 2022, with approximately 7-8% attributed to cement production [2, 3]. To meet the increased demand for cement manufacturing, energy-related fossil fuel production has also increased proportionally [4]. In 2021, the total global CO_2 emissions from the energy sector was 33 Gt [5].

In response to the growing need for Portland cement, alkaline-activated cement, or AAC, is a newly created sustainable and creative answer. The use of commercial activators, such as sodium hydroxide (NaOH) and sodium silicate or water glass (Na_2SiO_3), has been a highly concerned point even though AAC has garnered significant interest since it requires less energy and produces less CO_2 than Portland cement [6]. From an analysis that was conducted to evaluate the life cycle assessment of Sodium Hydroxide (NaOH), it was estimated that the production of one kilogram of NaOH consumes 3.5 MJ of fossil energy which is equivalent to 0.6329 kg of CO_2 emissions [7]. Therefore, the production of alkali activated cement (AAC) and geopolymer cement production are not completely sustainable due to the usage of commercial activators. In a nutshell, there is a key requirement of investigating completely sustainable processes of cement manufacturing, utilizing green aluminosilicate precursors, alkaline activators, and green admixtures.

Mine tailings are the left-over residue after extracting the target minerals from mined ore and it has been stored in tailing dams which are especially designed for maintaining a large capacity of tailings for long-term. However, there is a high-risk to fail this tailing dams due to the slope instability, foundation failure, overtopping and some external hazardous like earthquake or seepage. There is a high possibility of utilizing this mine tailings for developing eco-friendly cementitious composites either as fresh slurry or treated powder (oven-dried and ground to finer). Embracing a waste-to-wealth approach, this study aims to develop a sustainable, eco-friendly, cost-effective, high-strength cement while simultaneously reducing solid waste disposal and leveraging industrial and mining waste as a valuable resource. To achieve this aim, we are trying to optimize the mix design and curing condition, evaluating the compressive strength of binder at different curing periods. As well as the effect of microstructural and mineralogical variations of various mix designs would be investigated.

From the preliminary research study, it has been found out the required raw materials for the expected green cement binder such as coal combustion residue; fly ash, furnace slag from iron processing; ground granulated blast furnace slag, agricultural waste; rice husk ash and mining waste; gold and iron mine tailings. There are four different types of curing conditions which would be involved in this study including ambient (20 ± 2^0C/RH 50% ± 5%), hot-water (60^0C/RH > 95

%), moist (20 ± 2^0C/RH 97 ± 2%) and water curing (20 ± 1^0C). Finally, this innovative research study aims to contribute on the net zero carbon emissions by 2050, using the above stated green concept.

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