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Synthesis of ternary binders and sand-binder ratio on the mechanical and microstructural properties of geopolymer foamed concrete

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ABSTRACT

The development of sustainable construction building materials with a lower environmental impact throughout both the manufacturing and operation phases of the material lifecycle is capturing the attention of the global housing and construction sectors. Recent advancements have resulted in the development of geopolymer foam concrete, which combines the performance and energy savings associated with lightweight foam concrete with the cradle-to-grave emissions reductions associated with the use of a geopolymer binder composed of supplementary cementitious materials (by-products). The purpose of this study is to determine the influence of sand to binder ratio and by-product materials, fly ash, ground granulated blast furnace slag, palm oil fuel ash, palm oil clinker powder and bottom ash on structural grade geopolymer foamed concrete with a density of 1700 kg/m^3. The mechanical properties such as compressive strength, splitting tensile strength, rupture modules, and static and dynamic modules of elasticity were investigated; microstructure investigations using X-ray Diffraction (XRD) and Field-Emission Scanning Electron Microscope (FESEM) were also reported. The results show that geopolymer foamed concrete (GFC) with a structural grade concrete of compressive strengths ranging from 27 to 39 MPa could be produced. The use of fine sand improved the geopolymer foamed concrete's mechanical and microstructural characteristics. The tensile strength, modulus of rupture, and elasticity modulus were found in the ranges of 0.9 – 2.53 MPa, 1.35 – 4.28 MPa, and 3.54 – 6.86 GPa, respectively. The non-uniform distribution of the voids of ternary composites geopolymer foamed concrete and the formation of calcium aluminosilicate hydrates C-(N-) A-S-H gel are found.

1. Introduction

The overuse of virgin materials during the last 100 years in the normal weight OPC concrete depleted a huge amount of natural sources. In addition, the effects of carbon dioxide (CO_2) and its negative influence on the environment are well documented. Approximately 0.85 to 1.0 tonnes of CO_2 are released into the atmosphere for every tonne of Portland cement [1]. This issue forces the researchers to dig deep in their quest for alternative materials and also invest their time and efforts to reduce the CO_2 emissions due to the vast growing urbanization [2,3]. Though there have been multiple attempts to partially replace the conventional Ordinary Portland Cement (OPC) with the use of supplementary cementitious materials through industrial by-products and waste materials, still there are much more to be done to address this important issue. It has been shown that the whole replacement of OPC could be realised through other alternative materials by alkali activation and geopolymer concrete. Geopolymer concrete is the latest addition to the cementless concrete and is gaining momentum in different parts of the world and its development is inching towards sustainable construction material [4]. The by-product materials such as fly ash (FA), ground granulated blast furnace slag (GGBS), silica fume (SF), coal bottom ash (CBA) and palm oil industrial waste such as palm oil fuel ash

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