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Synthesis of sustainable lightweight foamed concrete using palm oil fuel ash as a cement replacement material

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A B S T R A C T

The replacement of conventional ordinary Portland cement with industrial by-products to produce cellular lightweight foamed concrete can have economic and environmental benefits. The performance of using a palm oil industrial by-product, namely, palm oil fuel ash (POFA), as a cement replacement material was investigated with proportions of 10, 20, and 30% to achieve a targeted oven-dry density of 1300 kg/m^3. Tests on compressive & splitting tensile strengths, water absorption, porosity, and sorptivity were carried out and analysed. Further, the microstructural analyses through X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy-dispersive X-ray (EDX) were conducted to correlate the test results. Non-destructive tests of ultrasonic pulse velocity and electrical resistivity tests were used for investigating the quality of concrete and corrosion resistivity. The results revealed that a replacement with 20% POFA produced slightly better performance compared to other mixes. A density reduction of about 43% with a replacement of 30% POFA was achieved in the development of non-structural foamed concrete. A reduction in compressive strength was noticed beyond 20% of POFA replacement and this could be attributed to the high amount of LOI, and porous nature of POFA; even though the UPV test results showed the foamed concrete as doubtful quantity the use of POFA as a sustainable material could be envisaged in such non-structural concrete. Furthermore, the SEM images shows the appearance of micro-cracks when 30% POFA was used. Moreover, the XRD results show a slight reduction in the intensity of the peaks of the crystalline phases when a higher quantity of POFA was used.

1. Introduction

One of the main concerns that affect our environment is the pollution caused by the emission of greenhouse gases. Carbon dioxide (CO_2) accounts for 81% of greenhouse gases in 2018 [1]; it is one of the main concerns that affects our entire ecological system, and contributes to an unsustainable future. In 2018, the total cement production around the world was about 4.1 billion tonnes [2]) and responsible for about 5–7% of total CO_2 emissions. It is well known that each ton of cement produces around 900 kg of CO_2, which is released into the atmosphere and results in pollution, and that cement production results in the depletion of natural resources [3].

It was estimated that the cement production in 2019 was 4.2 billion tons [4], which is estimated to produce 35 billion tons of concrete. The consequences of the use of billions of tonnes of natural resources in concrete is irreversible, and, in many parts of the world, the younger generations have started to recognize the exploitation of natural materials and its environmental effect. Thus, it is the right time for researchers, governments, non-governmental organizations, and academics, etc., to address this issue before a catastrophe occurs. One of the ways to minimize the exploitation of natural materials is to utilize the appropriate building materials that are available from industry as by-products or waste materials. The usage of industrial by-products has reformed the construction industry; if such materials are not utilized, it will cause tremendous damage to the land and water, as well as air pollution. In this context it has to be mentioned that countries such as Indonesia, Malaysia, and Thailand in the South East Asian region have many palm oil plantations; researchers utilized the palm oil wastes such

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