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A new method of producing high strength oil palm shell lightweight concrete

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ABSTRACT

This paper presents a new method to produce high strength lightweight aggregate concrete (HSLWAC) using an agricultural solid waste, namely oil palm shell (OPS). This method is based on crushing large old OPS. Crushed OPS are hard and have a strong physical bond with hydrated cement paste. The 28 and 56 days compressive strength achieved in this study were about 53 and 56 MPa, respectively. Furthermore, it was observed that it was possible to produce grade 30 OPS concrete without the addition of any cementitious materials. Compared to previous studies, significantly lower cement content was used to produce this grade of concrete. Unlike OPS concrete incorporating uncrushed OPS aggregate, this study found that there is a strong correlation between the short term and 28-day compressive strength.

1. Introduction

Typically, through the incorporation of various pozzolans and water reducers, high strength lightweight aggregate concrete (HSLWAC) has a compressive strength range of between 34 and 69 MPa. This concrete has a water to cement ratio of less than 0.45 and its air-dry density is less than 2000 kg/m^3 [1]. The use of high strength concrete (HSC) has many advantages such as a reduction in beam and column sizes, increased building height, greater span-depth ratio for beams in pre-stressed concrete construction and improved durability of marine concrete structures [2]. It can be said that HSLWACs have a significant advantage over normal weight HSC because of the reduction of dead load and construction cost. For instance, it has been reported that the length of high strength/high performance lightweight concrete prestressed bridge girders can be extended by 15–20% [3]. Furthermore, in some environments the use of HSLWC is mandatory. Haque et al. [4] investigated the strength development and durability of 35 and 50 MPa total lightweight concretes made with Lytag lightweight aggregate using 1, 3 and 7 days initial moist curing and then exposure to hot marine conditions for a period of 7 years. They suggested that it would not be wise to use LWC with a compressive strength of less than 50 MPa. In another example, it was reported that because of the limited bearing capacity of the soil, an all-LWC (a concrete mixture of 1840 kg/m^3 density and 41.2 MPa compressive strength) structure of 52 storeys was made as compared to a 35-storey structure using NWC [5].

There are different types of lightweight aggregate (LWA) with a wide range of properties. However, not all types of LWA are suitable for the production of HSC [6]. Oil palm shell (OPS) or palm kernel shell (PKS) are waste materials from the agricultural sector; products obtained in the processing of palm oil and are available in large quantities in tropical regions. It has been found that OPS can be used as a coarse aggregate for the manufacture of structural lightweight concrete and most researches have shown that producing OPS concrete with 28-day cube compressive strength of grade 35 or less is possible [7–13]. Okafor [7] reported that the maximum compressive strength of concrete produced using palm kernel shell aggregate is approximately 25–30 MPa. Basri et al. [8] used freshly discarded OPS in their study. They found that the compressive strength of OPS concrete is about 50% less than ordinary concrete. They produced grade 20 OPS lightweight concrete with low slump value. Mannan and Ganapathy [9] showed that by using 480 kg/m^3 ordinary Portland cement and free w/c ratio of 0.41, the 28-day compressive strength of OPS concrete is between 20 and 24 MPa, depending on the curing conditions. Furthermore, they reported [10] that the use of an accelerator such as calcium chloride ($CaCl_2$) results in higher strength of up to 29 MPa. The slump values for their study were lower than 10 mm. Mannan et al. [11] have used six types of preservatives, similar to preservative treatment to wood, to improve OPS and used it as coarse aggregate. The highest 28-day compressive strength of about 33 MPa with slump value of 95 mm was reported in this study. Alengaram et al. [12] reported that the 28-day compressive strengths of the mixes containing cementitious materials were in the range of 26–36 MPa and slump value was in the range of 0–160 mm. They used cement content in the range of 440–530 kg/m^3 with 5% fly ash (FA) as cement replacement and 10% silica fume (SF) as additional cementitious material. A recent study conducted by Shafigh et al. [13] revealed that OPS

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