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Adopting particle-packing method to develop high strength palm oil clinker concrete

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ABSTRACT

Utilization of locally available waste and by-product to replace conventional concrete materials has gained considerable attention over the past two decades. This study is a part of an extensive research program on the characteristics of palm oil clinker (POC) incorporated concrete. In this study, experimental investigation was carried out on incorporating POC as aggregates and filler material in the production of high strength concrete (HSC). Crushed POC were used as partial and full replacement of natural aggregates i.e. fine and coarse. Palm oil clinker powder (POCP) was then incorporated to fill the voids present on the surface of POC particles, while maintaining the other mix constituents. Fresh and hardened properties of the POC concrete with and without POCP were investigated. Substituting coarse aggregate with POC negatively affected the concrete fresh and hardened properties due to POC porous nature. However, the results of the study revealed that incorporating additional POCP as filler material by adopting Particle-Packing (PP) method improved the engineering properties of POC concrete. Therefore, there is a potential towards utilization of POC for many practical construction applications. POC being an environmentally-friendly and a low-cost aggregate can serve as a normal aggregate alternative for future use.

1. Introduction

Generation of large amounts of waste materials and their discarding are some of the great issues confronted by present day civilization (Kleemann et al., 2016). Thus, researchers are exploiting the option of using solid waste and its by-products in construction (Alnahhal et al., 2017; Alsubari et al., 2016 ; Bashar et al., 2016). The industrial sector generates a high amount of waste due to the continuous development it is undergoing. Often, these wastes are dumped off to sites, and they become hazardous leading to environmental pollution (Babel et al., 2009). A basic strategy being practiced to mitigate problems related to solid waste is the recovery of reusable raw materials from waste, (Hussein and Muda, 2012). This is achievable by exploring the possibility of utilizing these wastes as an alternative to existing products; such as incorporating waste as aggregate alternatives in the production of concrete (Abutaha et al., 2016). The volume of concrete used in the world makes the cement and concrete industry a large contributor to the global CO2 emissions (Kleijer et al., 2017). Hence, adopting waste aggregates in production of concrete is an appropriate approach towards sustainable construction (Senthamarai and Manoharan, 2005). The resultant concrete which is referred to as recycled aggregate concrete, would create a sustainable end use for concrete waste, and reduce the demand for normal aggregate, leading to its preservation (Wijayasundara et al., 2016). Developing countries can benefit from utilizing agricultural waste as partial and full material replacement in the construction industry rather than dispose them conventionally (Alsubari et al., 2018; Mannan and Ganapathy, 2004). Also, industrial wastes can be used as raw materials especially in the production of concrete (Halicka et al., 2013). POC is a waste material from agricultural sector resulting from the incineration of palm oil shell in the form of light solid fibrous material. POC is available in the form of solid lightweight material in varying sizes between 20 and 150 mm. Typically, POC is obtained in a large chunk and it is porous in nature with a sharp and rough broken edges, and often flaky with an irregular shape as shown in Fig. 1. POC serves as possible aggregates in the production of concrete when crushed to required size (Abutaha et al., 2016; Ibrahim et al., 2017 Ibrahim et al., 2017). Mohammed et al. (2014) reported that Oil Palm Shell (OPS) and Oil-Palm-Boiler Clinker (OPBC) are used as an alternative lightweight aggregate (LWA) in tropical regimes and countries that have a palm oil industry. Kanadasan and Abdul Razak (2015a) study revealed that incorporating POC in concrete can save cost, reduce carbon emission and energy consumption. Consequently, this study evaluates the effect of POC incorporation as aggregates and filler material on the engineering properties of high

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Fig. 1. Palm oil mill waste.

strength concrete (HSC). The purpose is to examine the feasibility of using palm oil waste and its by-products in terms of its possible application as natural aggregates replacement in the production of concrete towards a sustainable construction. This research also addresses the sustainable exploitation of POC by ensuring the proper utilization with a suitable mix design.

2. Materials

2.1. Aggregates

Materials used in the production of the HSC are four types of aggregate including; silica sand and crushed granite rocks as natural fine and coarse aggregate respectively, POC was crushed and utilized as natural aggregate replacement i.e. coarse and fine (Fig. 2). Table 1 and Fig. 3 presents the physical characterization and the sieve analysis

Table 1
Physical characteristics of aggregates.

Properties	Aggregates			
	Fine Aggregate		Coarse Aggregates	
	Silica Sand	POC Fine	Granite	POC
Aggregate size (mm)	< 4.75	< 4.75	4.75–10	4.75–10
Specific gravity (SSD)	2.69	2.15	2.57	1.81
Water absorption (%)	1.41	5.75	0.59	4.35
Moisture content (%)	0.08	0.11	0.23	0.28
Aggregate crushing Value (%)	–	–	17.93	56.44
Bulk Density (kg/m^3)	1301	811	1452	732

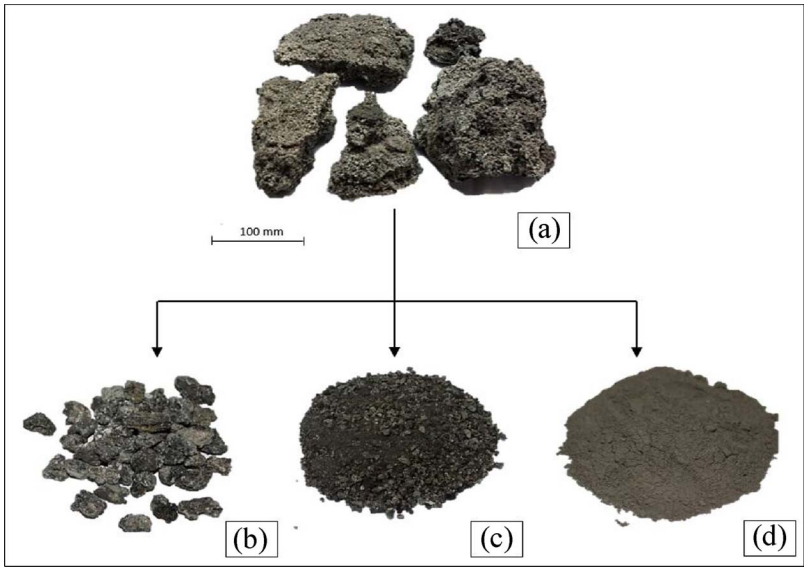

Fig. 2. POC (a) large chunk (b) coarse (c) fine (d) powder.

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