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Research Article

Micro Fine Sized Palm Oil Fuel Ash Produced Using a Wind Tunnel Production System

R. Ahmadi,[1] N. Zainudin,[1] I. Ismail,[1] M. A. Mannan,[1] and A. S. Z. Abidin[2]

[1]*Department of Civil Engineering, University Malaysia Sarawak, 94300 Samarahan, Sarawak, Malaysia*
[2]*Department of Mechanical and Manufacturing Engineering, University Malaysia Sarawak, 94300 Samarahan, Sarawak, Malaysia*

Correspondence should be addressed to R. Ahmadi; araudhah@unimas.my

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Micro fine sized palm oil fuel ash (POFA) is a new supplementary cementitious material that can increase the strength, durability, and workability of concrete. However, production of this material incurs high cost and is not practical for the construction industry. This paper investigates a simple methodology of producing micro fine sized POFA by means of a laboratory scale wind tunnel system. The raw POFA obtained from an oil palm factory is first calcined to remove carbon residue and then grinded in Los Angeles abrasion machine. The grinded POFA is then blown in the fabricated wind tunnel system for separation into different ranges of particle sizes. The physical, morphological, and chemical properties of the micro fine sized POFA were then investigated using Laser Particle Size Analyser (PSA), nitrogen sorption, and Scanning Electron Microscopy with Energy Dispersive X-Ray (SEM-EDX). A total of 32.1% micro fine sized POFA were collected from each sample blown, with the size range of 1–10 micrometers. The devised laboratory scale of wind tunnel production system is successful in producing micro fine sized POFA and, with modifications, this system is envisaged applicable to be used to commercialize micro fine sized POFA production for the construction industry.

1. Introduction

The palm oil industries in Malaysia, being the second largest palm oil producer in the year 2010, are producing up to 4.5 million tons of waste per year [1, 2]. This solid waste or by-product, known as palm oil fuel ash (POFA), is abundant and if not disposed properly may contribute to serious environmental problem which could be harmful to mankind [3].

In recent years, POFA is found to have high potentials as a new alternative material for concrete and construction industry since it possesses pozzolanic properties [3–8]. The pozzolanic reaction between silica oxides and calcium hydroxide during the hydration process in concrete will produce calcium silicate hydrate, a gel compound that supports the production of stronger and denser concrete [9, 10]. Utilizing POFA as a supplementary cementitious material is anticipated to produce concrete with properties of high strength with resistance to adverse environment condition.

In the earlier studies, POFA had been claimed as not suitable for replacing cement in concrete for more than 10–20% by mass of cement if high compressive strength concrete is to be achieved [3, 11, 12]. Nevertheless, another study pointed out that 40% replacement of cement using micro fine size POFA contributes to high strength concrete achieving compressive strength up to 112 MPa which is 14% higher than normal strength of Ordinary Portland Cement (OPC) concrete [13].

In terms of physical properties, micro fine size POFA has a lower specific gravity, smaller median particle size, and greater specific surface area [12, 14] which contributes to improvement of workability in fresh concrete. A study demonstrated that the finer size of POFA contributes significantly to packing effect and pozzolanic reaction in cement paste [12]. However, these factors depend on the curing ages and the percentage of fine size POFA as cement replacement material in concrete.

Until today, an economical way of producing micro fine size POFA is not well established. Due to the significant contribution of micro fine size POFA as supplementary cementitious material, a new approach to produce this material using a wind tunnel system is carried out. This method is simple and economical in order to separate the micro fine size POFA into