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# Characteristics of Artificial Lightweight Aggregates Produced from Palm Oil Fuel Ash and Fly Ash Using Cold-Bonding

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**Abstract**

Crushed stone aggregates are commonly used in the construction industries and can lead to the depletion of natural resources if used excessively. To avoid this from happening, the incorporation of wastes and by-products as alternative materials in artificial lightweight aggregates (ALWA) production has become a major area of interest recently. In Malaysia, palm oil fuel ash (POFA) and fly ash (FA) are by-products which are abundantly available and could contribute towards environmental pollution if not properly managed. The main aim of this research is to determine the characteristics of ALWA made from POFA and FA using cold bonding method. In this research, two different types of NaOH molarity (8M and 10M) and a constant ratio of sodium silicate to sodium hydroxide (1:1) were used as alkali activators. The percentage of POFA to FA used in this research was 80% and 20%, respectively. From the results obtained, it was observed that the bulk density and particle density of POFA FA aggregates increase as the molarity of NaOH increases. On the other hand, the water absorption of the POFA FA aggregates was found to decrease from 8.3 to 7.1% when the molarity of NaOH was increased from 8M to 10M. The experimental results of the crushing strength show that POFA FA aggregates with higher molarity of NaOH (10M) shows a better crushing strength as compared to POFA FA aggregate with lower molarity of NaOH (8M).

***Keywords:*** *Lightweight Aggregates, By-products, Crushing Strength, Water Absorption.*

## 1. Introduction

In Malaysia, rapid growth of the construction industry in conjunction with economic growth has led to an increase in the production and consumption of construction materials such as rock material (natural aggregate) to fulfill its demand nowadays. Concrete is one of the most commonly used material in the construction industry. Since concrete is made up of approximately 70% aggregate, massive production of these naturally occurring aggregates is required and consequently contributes towards environmental degradation. Natural aggregates obtained by adopting the blasting method at quarry sites may cause hazard to livelihood and the surrounding earth structure. In Malaysia, about 300 quarry sites extract a total of 110,339,000 tonnes of aggregates in year 2012 [1]. Although the source of natural aggregate is still adequate for the current situation, however, aggressive consumption of non-renewable aggregates can cause depletion in the future if the planning of natural aggregate exploitation is inappropriately done.

At the same time, industrial solid waste pollution has become a serious environmental problem in the world. The growth of industries is increasing due to the rapid change in population, and as a result, a large amount of industrial solid wastes is generated and dumped in landfills without any profitable return. Fly ash (FA) and palm oil fuel ash (POFA) are industrial waste materials commonly found in Malaysia. FA is a finely divided ash collected from the combustion of pulverised coal in electric power generating plants. Currently, about 42.5% of electricity in Malaysia is produced by means of coal firing, which consumes about 8 million tonnes of coal in year 2015 [2]. Since fly ash represents approximately 58% of coal combustion products as waste material [3], it is estimated that a total of 4.7 million tonnes of fly ash was generated in the year 2015. FA has been regarded as one of the 27 products in the family of common cements as stated in BS EN 197-1 [4] and it has been identified as 'pozzolanic material' used to partially replace ordinary Portland cement (OPC) in cement production. In Malaysia, FA has been used in the construction of some structures which includes the Petronas Twin Towers, Second Malaysia-Singapore Causeway [5], and roller compacted concrete dam [6]. However, the usage of FA is still not widely applied in the construction industry. On the other hand, POFA is an ash-formed waste material produced from the burning of palm oil fibre and palm oil shell as fuel in the boilers of the palm oil industry. In Malaysia, oil palm serves as one of the most important crops which accounts for 37% of world