The Performance of Ultrafine Palm Oil Fuel Ash in Suppressing the Alkali Silica Reaction in Mortar Bar

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Abstract— **This study evaluates the effect of ultrafine palm oil fuel ash (POFA) on the alkali silica reaction (ASR) of mortar. To study the effectiveness of ultrafine POFA in suppressing the ASR, four different sizes of POFA were used in this study: the unground (UG), medium (MP), fine (FP), and ultrafine size (UF). Characterization of POFA was done to investigate their particle size, fineness, specific gravity, chemical composition, loss on ignition (LOI), and morphology. Initially, the pessimum effect of the sandstone aggregate was determined by blending 5, 15, 50, 75, and 100% of sandstone aggregates with the granite. POFA was then introduced as cement replacement at 0 - 40% by weight of binder. To investigate the effect of ultrafine POFA on ASR, ASTM C1260 and ASTM C1567 were adopted. The strength activity index was also determined to study the pozzolanic effect of the ultrafine POFA. Results show that the ultrafine POFA significantly increase the pozzolanic reactivity of mortar. At 14-days of testing, ultrafine POFA shows higher resistance against the alkali silica reaction (ASR) attack compared to coarser POFA. Higher level of replacement is required for coarser POFA to resist ASR attack in the mortar bar.**

***Index Terms*— Alkali Silica Reaction, Palm Oil Fuel Ash, Reactive aggregate, Ultrafine.**

I. Introduction

As the second largest palm oil producer in the world, Malaysia has generated million tonnes of palm oil wastes each year. Combustion of palm oil shell and fiber has produced another secondary palm oil waste known as palm oil fuel ash (POFA). With no commercial value, these ashes were dumped near the plantation area [1] and caused air, water and land pollution [2]. Many efforts have been done to use POFA in concrete; however, the coarser size of POFA has led to a decrease in the strength of concrete [3]. This has limited the use of POFA in concrete construction. Later, it was found that grinding process can improve the quality of POFA. The amount of cement replacement increased up to 30% with improvement on the strength and durability of concrete as compared to conventional concrete [4]. These encouraging results lead to further efforts to grind POFA into higher fineness through the process of grinding and heat treatment. A better quality POFA known as ultrafine POFA has been produced, which further enhances the engineering properties and durability of concrete due to its high pozzolanic reactivity and micro-filler effect [5]. Since then, research of ultrafine POFA has been gaining attention among the researchers and more studies need to be performed on ultrafine POFA so that knowledge on POFA can be well-established.

Alkali silica reaction (ASR) occurs due to the reaction between silica from the reactive aggregate and alkali from the cement, which leads to the formation of alkali silica gel [6]-[7]. In the presence of moisture, this gel will expand [8] and eventually causes concrete to crack [9]. Three factors affect ASR occurrence, which are reactive aggregates, high alkali cement and presence of moisture. In Sabah, most of the quarries are producing sandstone aggregates, which is considered as reactive [10]. This signifies that the aggregates are prone to the exposure of high alkaline solution. Higher alkalinity will increase the amount of hydroxyl ion (OH^-), which is responsible for the dissolution of silica from the reactive aggregate [11]. Reaction of silica and the hydration product of cement will form alkali silica gel, which swells in the presence of moisture. To reduce the ASR, the main option is to use the non-reactive aggregate. However, since it is difficult to find non-reactive aggregate in some countries, another way is to replace parts of the cement with the pozzolan. Previous study revealed that POFA has the ability to suppress the ASR [12], but since the information is very limited, not much knowledge on the effect of ultrafine POFA on ASR is available. Realizing that, this paper aims to investigate the effects of ultrafine POFA on the alkali silica reaction of mortar bar.

II. Materials and Methods

A. Materials Preparation

The materials used in this study were Ordinary Portland cement (OPC) Type I, palm oil fuel ash (POFA), coarse aggregates, granite, and river sand. Coarse aggregates were sandstone aggregates which were obtained from Penampang and Telipok quarries. The coarse aggregates were washed and open-dried for several days before it was crushed into various sizes according to ASTM C 1260 [13]. River sand was also dried and sieved to pass the 600 µm sieve. The physical properties of aggregates are shown in Table I.

POFA used in this study was collected from Lumadan Palm Oil Mill in Sabah, Malaysia. The ashes were collected at the bottom of the tower shaft where it was trapped by a pond of water. The moisture content of the original POFA was 20% with specific gravity of 1.96. To remove the excess moisture, POFA was open-dried in lab condition for several days before it was placed in the oven at a temperature of 105

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