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A Study of the Performance of Palm Oil Fuel Ash in Suppressing the Effect of Alkali Silica Reaction in Mortar Bars

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---***ABSTRACT***--
This research considers the effectiveness of Palm Oil Fuel Ash (POFA) in suppressing the Alkali Silica reaction in mortar bars. Mortar bars with POFA replacing Portland Cement by 0, 10, 20, 30, 40 and 50% were cast, demoulded after 24 hours, weighed and immersed in 1N Sodium Hydroxide (NaOH) solution. Measurements of the mortar bar weights were carried out after 6, 12, 18, 24 and 30 days immersion in NaOH solution, each time the bars being immersed in fresh NaOH solution. The percentage increase in the weights of the mortar bars at 0%, 10%, 20%, 30%, 40% and 50% replacement levels were 8.5%, 8.2%, 9.9%, 10.9%, 12.4% and 13.5% respectively which showed that the inclusion of POFA of not more than 10% was able to suppress the expansion of mortar bars resulting from alkali-silica reaction. It is thus recommended that application of POFA in the right dose will suppress alkali silica reaction.
KEYWORDS:*alkali silica reaction, mortar bars, palm oil fuel ash, portland cement*

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I. INTRODUCTION

Aggregates were for a long time considered to be inert but this view had to be discarded when it was discovered that some aggregates contain reactive silica which react with alkalies present in cement (Shetty, 2009; Yurtdas et al. 2013 and Ichikawa, 2009). Four factors have been identified as promoting alkali silica reaction and these are reactive aggregates, high alkali content in cement, availability of moisture and optimum temperature conditions (Shetty, 2009). Reactive aggregates are prone to 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 (Lytton et al. 2010 and Asra et al. 2015). Reaction of silica and the hydration product of cement will form alkali silica gel which swells in the presence of moisture. The best way to mitigate the alkali silica reaction is to make use of non-reactive aggregates. However, research findings have indicated that the use of some pozzolans such as Palm Oil Fuel Ash (POFA) to replace part of cement in concrete can suppress the alkali silica reaction (Awal and Hussin, 1997).

II. MATERIALS AND METHODS

Materials

The Palm Oil Fibres used for this study was sourced from local palm oil producers in Obaagun, Nigeria. The Fibres were burnt to ashes in specially prepared drum under controlled air. The resulting ashes were sieved using 600µm sieve. The chemical analysis of the ash was carried out using X-ray Fluorescent Analyser in Lafarge Cement WAPCO Nigeria Plc, Sagamu, Nigeria. The Ordinary Portland Cement (Dangote Brand) used was obtained from local suppliers. Sharp sand was collected from the drains and was sieved using 5mm size sieve.

EXPERIMENTAL PROGRAM

Evaluation of the effectiveness of POFA in suppressing Alkali Silica Reaction in mortars was investigated using ASTM C 1260 – Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar – Bar Method). Mortar bars (25 x 25 x 250 mm) were cast and cured for 48 hours. The mortar bars were made using 1 part of cement to 2.75 parts of sand by mass. Water – cement ratio by mass of 0.47 was used. Six sets of mortar bars were produced by replacing OPC with POFA at 0, 10, 20, 30, 40 and 50% levels (Figure 1). The mortar bars were placed in a 1N Sodium Hydroxide solution and mass change data was collected for 30 days.

Figure 1: Mortar Bars Before Immersion in Sodium Hydroxide (NaOH) solution

III. RESULTS AND DISCUSSION

Chemical Composition of POFA

The chemical composition of POFA is shown in Table 1. The total amount of SiO_2, Al_2O_3 and Fe_2O_3 is 76.04% for POFA which is more than70%, requirement which a good pozzolan for manufacture of blended cement should meet (Shihembetsa and Waswa-Sabuni, 2002; Pekmezci and Akyuz, 2004). The requirements of ASTM C 618 for a combined SiO_2+Al_2O_3+Fe_2O_3 of more than 70% was also satisfied (Siddique, 2004). Thus, POFA is a suitable material for use as a pozzolan. The presence of Silica, Alumina and Iron is responsible for the formation of cementitious products when they react with lime in the presence of water.

Table 1 Chemical Composition of Palm Oil Fuel Ash (POFA)

Chemical Constituents	Percentage Composition %
SiO_2	69.46
Al_2O_3	3.68
Fe_2O_3	2.90
CaO	1.63
MgO	0.51
SO_3	0.55
Na_2O	0.06
K_2O	3.91
P_2O_3	1.47
LOI	9.91

Effect of POFA on Alkali Silica Reaction

The results of the reaction of POFA mortar bar specimens with Sodium Hydroxide (NaOH) solution are presented in Table 2. The detail of the percentage change in mass of mortar bar specimens at each exposure in sodium hydroxide solution is plotted in Figure 2. All the mortar bars experienced gain in mass as a result of the expansion of the mortar bars. After 30 days immersion in sodium hydroxide solution, the percentage increase in the masses of POFA mortar bars at 0%, 10%, 20%, 30%, 40% and 50% replacement levels were

8.5%, 8.2%, 9.9%, 10.9%, 12.4% and 13.5% respectively. It can be seen that the increase in mass of the control mortar bars were more than the increase in mass of the 10% POFA mortar bars. This shows that the inclusion of POFA of not more than 10% was able to suppress the expansion of mortar bars resulting from alkali-silica reaction. This observation is in agreement with the findings of some other researchers (Abdul Awal and Hussin, 1997; Asrah et al., 2015). The reason is that the pozzolanic POFA particles reacted rapidly with the alkalis present in cement because of the reactive nature, thus leaving very little unreacted alkalis for the latter reaction with reactive aggregate (Abdul Awal and Hussin, 1997). The appearance of mortar bars after immersion in NaOH solution is as shown in Figure 3.

Table 2: Reaction of POFA Concrete with Sodium Hydroxide

Percentage POFA (%)	Effect of NaOH on	Duration of Immersion in Sodium Hydroxide (Days)					
		0 Day	6 Days	12 Days	18 Days	24 Days	30 Days
0	Mass (g)	428.2	463.3	463.7	463.7	464.2	464.6
	Change (g)		35.1	35.5	35.5	36.0	36.4
	% Change		8.2	8.3	8.3	8.4	8.5
10	Mass (g)	421.4	455.5	455.5	455.9	456.0	456.0
	Change (g)		34.1	34.1	34.5	34.6	34.6
	% Change		8.1	8.1	8.2	8.2	8.2
20	Mass (g)	414.9	454.7	455.1	455.2	455.6	455.9
	Change (g)		39.8	40.2	40.3	40.7	41.0
	% Change		9.6	9.7	9.7	9.8	9.9
30	Mass (g)	400.0	442.4	443.2	443.3	443.6	443.6
	Change (g)		42.4	43.2	43.3	43.6	43.6
	% Change		10.6	10.8	10.8	10.9	10.9
40	Mass (g)	392.7	437.1	438.3	439.0	439.4	441.4
	Change (g)		44.4	45.6	46.3	46.7	48.7
	% Change		11.3	11.6	11.8	11.9	12.4
50	Mass (g)	390.1	441.2	441.3	441.6	441.6	442.8
	Change (g)		51.1	51.2	51.5	51.5	52.7
	% Change		13.1	13.1	13.2	13.2	13.5

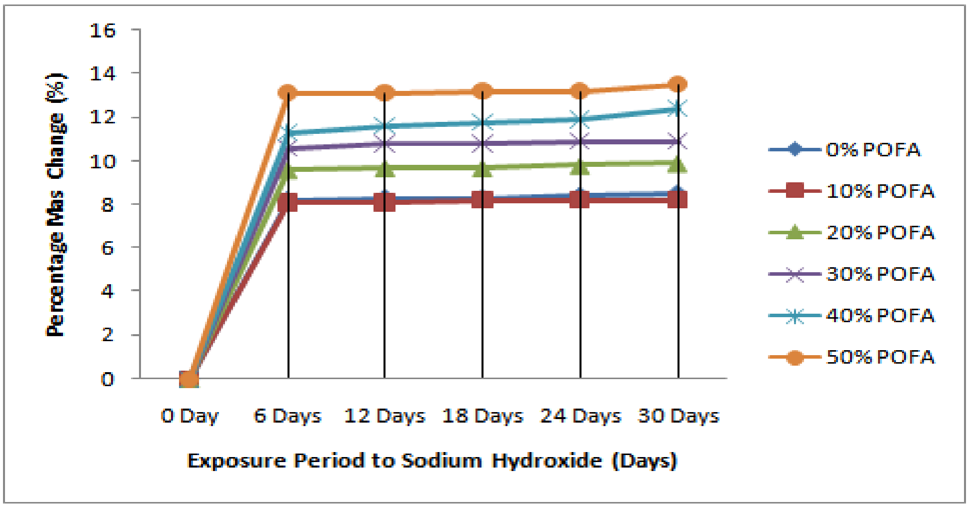

Figure 2: Effect of Sodium Hydroxide on POFA Mortar bars

Figure 3: Mortar Bars After Immersion in Sodium Hydroxide (NaOH) solution

IV. CONCLUSIONS

The following conclusions can be drawn from this study:

Palm Oil Fuel Ash (POFA) is effective in suppressing the Alkali Silica reaction.

The optimum dosage of POFA to suppress the Alkali Silica reaction is 10% by weight replacement of Portland cement.

RECOMMENDATIONS

The utilization of Palm Oil Fuel Ash (POFA) to suppress the Alkali Silica reaction should be encouraged.

Further studies on the application of POFA to suppress Alkali Silica reaction should be carried out.

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