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Effects of Palm Oil Fuel Ash (POFA) Towards Consistency and Setting Time Properties of Concrete

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Abstract. Malaysia is having an environmental problem in disposing palm oil fuel ash (POFA) which is a byproduct of palm oil mill since many years ago. Due to this concern, it may be utilized in a concrete as one of the supplementary cementatious material (SCM). This research is to study its setting time of each sample by replacement of cement using liquidation and powder technique. The replacement percentage used for this research is 5% POFA and 10% POFA. Through this research, mixture with 5% POFA using liquidation technique has the highest setting time.

INTRODUCTION

POFA is found having a high pozzolanic material and it is not just can be used as partial cement replacement but also can increase the compressive strength and durability of concrete. The applications of pozzolans in concrete give better result in 30% optimum mixing which is more 10% better than the normal concrete. ASTM C 618-92a has classified POFA in Class C as chemical analysis [1].

Pozzolan can be define as a broad class of siliceous or siliceous and aluminous materials which, in themselves, possess little or no cementitious value. But it will in finely divided form and in the presence of water, it react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties [2]. There are some researchers that had done a study on the various size of the same admixture in concrete or mortar. From his journal stated that according to Rukzon et al, the size of pozzolan particle have a huge influence to the properties of the mortar or concrete. It can influence the packing effect and pozzolonic activity. By improving the packing effect and pozzlonic properties, it can improve the durability of the concrete and mortar through the pore refinement and reduction of Ca(OH)2 [3].

As the fineness of POFA increased, the content of the SiO2 also will increase and will resulted in the increment of silica content. The chemical content of POFA had been influenced by the size of the POFA particle or the level of their fineness [4]. From the researched conducted by [5] the compressive strength of cement blended with POFA showed cement with 10% POFA has the highest compressive strength compared to 30% and 50% of POFA. The result from this research presented that the cement with 10% replacement with POFA almost have the same compressive strength with the control sample which is 48.379 N/mm². As a suggestion by the researcher, in order to increase the compressive strength of the concrete using POFA, smaller particle size of the POFA need to be used by grinding it or burning in order to obtain more fineness structure of POFA. By burning and grinding it more further, the silica content in POFA can be increased and thus will increased the compressive strength of the concrete [5].

The usage of POFA in concrete will be applied in the construction of rigid pavement in Malaysia. This is because rigid pavement has sufficient flexural strength. Apart from its sufficient flexural strength, the life span of flexible pavement is much more compared to the flexible pavement with low maintenance [6].

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METHODOLOGY

This research is to study the effects of POFA towards physical properties in concrete for rigid pavement. The preparation for physical properties in concrete as shown in Fig.1 below.

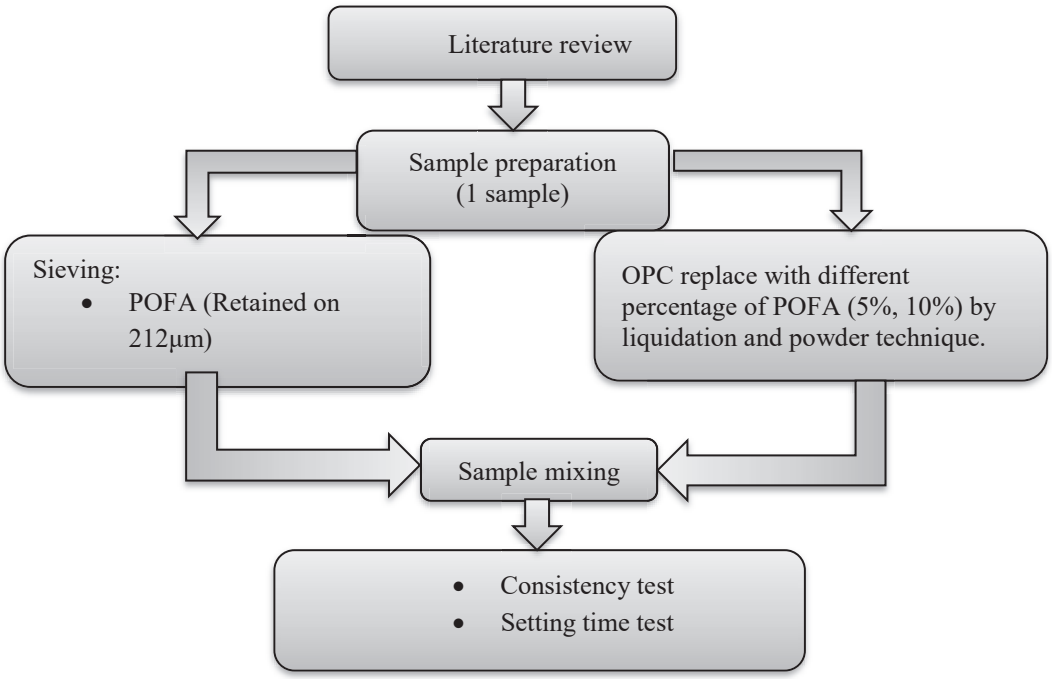


FIGURE 1. Flowchart of research methodology

Preparation for Physical Properties

There were 2 types of testing that carried out in this study in order to determine the physical properties of POFA in concrete which were Consistency test and Setting time test. Before proceed to the testing, the POFA need to be prepared first. The percentage of POFA used is by the percentage of weight of cement as shown in Table 1 below.

TABLE 1. Amount of Cement and POFA for Each Sample Using Powder and Liquidation Method

Number of Sample	Amount of cement (g)	Amount of POFA (g)
1(Control Sample)	400	0
2 (5% POFA)	380	20
3 (10% POFA)	360	40

Preparation of POFA

There were 4 steps in order to do preparation of POFA. Step 1 was finding which POFA had been obtained at Nibong Tebal at palm oil factory. As POFA is a waste, there will be no cost or fee that need to be paid. After that for step 2 was drying which means the POFA had been put inside oven and had been dried up to 24 hours. This is to eliminate its moisture content and it will be easy to obtain the required size of POFA's particle in sieving stage. Step

3 was sieving. POFA had been sieved and POFA that retained at 212 μm had been used for this research. Last but not least, step 4 was liquidation of POFA. POFA had liquefied using ratio 1kg POFA using 200ml water. This liquefied POFA had been used during replacement of cement using liquidation technique. Figure 2 shows the POFA which is before being sieved.

FIGURE 2. POFA before being sieved

Consistency Test

In order to determine the physical properties of POFA in concrete, there were several step. Step 1 was preparation of cement and POFA. For control sample, a 400g cement had been prepared. For sample with POFA, 5% and 10% of cement weight had been replaced. After that, the material needs to be mix which for step 2. Cement had been mixed with 120 ml water as starter. Then final step was the penetration. Consistency test for this research is based on BS EN 196-3: 2005 using Vicat apparatus. After cement had been mixed with water, the paste had been filled inside mould. Plunger then had been brought into contact with the top surface of cement paste and released. The penetration depth should be between 5mm-7mm from bottom of the mould. If the penetration is less than 5mm, water need to be reduced and if the penetration is more than 7mm, then water need to be added. The whole process need to be done in 5 minutes.

Setting Time Test

Setting time test for this research was based on ASTM-C 150-09. Needle on Vicat's apparatus had been replaced. For initial setting time test, the needle used was a round needle with diameter 1.13 mm. The needle had been brought into contact with top surface of cement paste and released. Initial setting time had been said to take place when the needles can only penetrate 5mm and below.

After initial setting time had took place, needle had been replaced for final setting time. Final setting time had been said to take place when needle that gently brought to the surface penetrate 0.05 mm and the circular cutting edge fail to make any impression on top of the cement paste.

RESULTS AND DISCUSSIONS

Consistency

Table 2 and Table 3 show the amount of water for control sample and cement paste with 5% and 10% of POFA based on powder and liquid technique respectively. For this research, the penetration of plunger had been fixed to 6mm for each sample.

TABLE 2. Result consistency for powder technique

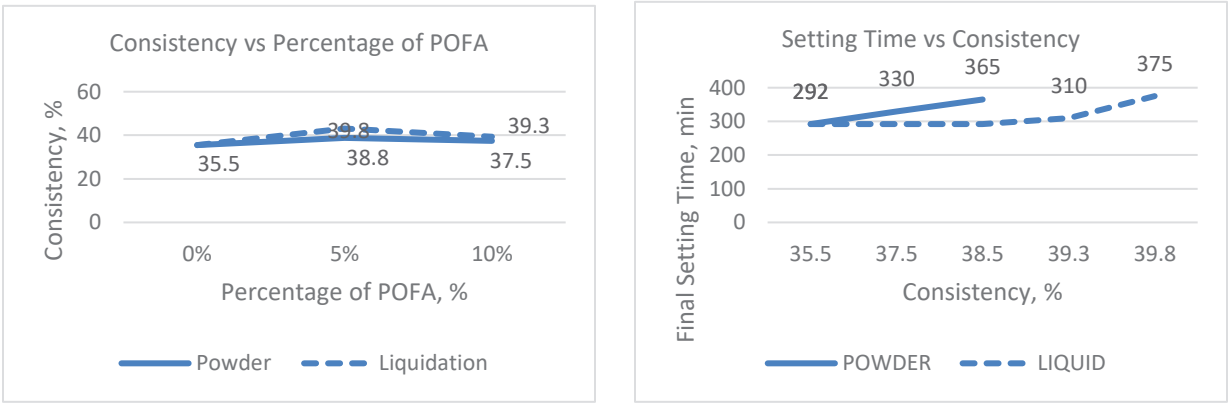
Weight of cement (g)	Percentage of POFA (%)	Amount of water (ml)	Penetration (mm)	Water percentage (%)
400	0	142	6	35.5
400	5	155	6	38.8
400	10	150	6	37.5

For powder technique, result above have shown sample with 5% POFA have the highest percentage of water while control sample have the lowest water percentage which indicate that it only used the least amount of water to achieve its consistency. It also can be stated that the more percentage of POFA used, the more water needed for the cement paste to achieve standard consistency. The consistency of control sample was 35.5% while for 5% and 10% were 38.3% and 37.5% respectively.

TABLE 3. Result consistency for liquidation technique

Weight of cement (g)	Percentage of POFA (%)	Amount of water (ml)	Penetration (mm)	Percentage of water (%)
400	0	142	6	35.5
400	5	159	6	39.8
400	10	157	6	39.3

Table 3 above indicates the result for consistency test for liquid technique. Using liquid technique, sample with 5% POFA has the highest percentage of water while control sample has the lowest percentage of water which are 39.8% and 35.5% respectively. Sample with 10% POFA is 3.7% higher than control sample while having percentage of water by 39.9%.



(a) (b)

FIGURE 3. (a) Graph of Relationship between Consistency and Percentage of POFA (b) Graph of Relationship between Setting Time and Consistency

From Figure 3(a) above, the consistency for sample with POFA as replacement is higher compared to control sample. Consistency of each sample had been influenced by the amount of water being added to the cement paste during the consistency test using Vicat apparatus. POFA will absorb water from the mixture and hold the water in the

system for better finishing surface and workability [2]. The amount of water used during consistency test will directly affected setting time for each sample. From the Figure 3(b) above, the higher the consistency percentage, the higher the setting time for the sample. This is because, the initial water used during consistency test for the sample is high. As the water used is high, it will take longer time for the cement paste to harden. The journal stated that there are two important parameters that will greatly affected the amount of water when using a natural pozzolan as a cement replacement [2]. In order to achieve low water amount, the shape of natural pozzolan must not be long and elongated and pozzolan must have a satisfactory fineness.

Setting Time

Table 4 show the initial and final setting time for control sample and sample with 5% and 10% replacement of POFA.

Table 4. Initial and final setting time for powder technique

Percentage of POFA (%)	Initial setting time (min)	Final setting time (min)
0 %	178	292
5%	220	365
10%	195	330

Table 4 shows that the higher the percentage of POFA used, the longer it takes for the sample to set. The control sample have final setting time of 292 min while for sample with 5% and 10% POFA have the final setting time of 365 min and 330 min respectively. The time for the cement paste to set can be relate to the consistency of the cement paste. From Table 4 the control sample have the lowest amount of water which is 142 ml and sample with 5% POFA have the higher amount of water required which is 155 ml.

Table 5. Initial and final setting time for liquidation technique

Percentage of POFA (%)	Initial setting time (min)	Final setting time (min)
0 %	178	292
5%	245	375
10%	215	310

From Table 5 above, sample with 5% POFA have the longest setting time compared to sample with 0% and 10% POFA. Setting time was 292 minutes, 375 minutes and 310 minutes respectively. Setting time of sample with 5% POFA using liquidation technique is higher than sample with 5% POFA using powder technique.

CONCLUSION

As mentioned all the way, this research used replacement percentage of cement is 5% POFA and 10% POFA whereby each percentage were using powder technique and liquidation technique. Through this research, the results indicates that sample with 5% replacement of POFA using liquidation technique has the highest consistency and setting time by 39.8% for consistency and 375 min for setting time. The usage of POFA should be utilized in the production of rigid pavement as it will save up the cost of constructing rigid pavement. Other than that, rigid pavement have long life durability and required low maintenance cost throughout its life span. By utilising POFA it can help to reduce environmental problem that Malaysia had been facing as one of the largest country to export palm oil. The

results from the research had demonstrated that with the replacement of cement using POFA, it will help in the plastic consistency properties and setting time.

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