SHORT INVESTIGATION ABOUT DEVELOPMENT OF STRENGTH MORTAR CONTAINING PALM OIL FUEL ASH (POFA) AND PULVERISE FUEL ASH (PFA)

T. Mehmannavaz[1]*, S. R. Sumadi[1], M. A. R. Bhutta[1], P. Forouzani[1],

M. Samadi[1] **, S. M. Sajjadi[1] and O. Farahmandpour[1]

[1] *Department of Structures and Materials, Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*

ABSTRACT

Incorporation of Palm Oil Fuel Ash (POFA) and Pulverized Fuel Ash (PFA) as partial cement replacement material in mix of mortar would decrease the amount of cement use and reduces the high dependency on cements compared to ordinary mortar. The result of this research is to support the use of new concept to prepare mortar for industrial construction. The strength of mortar with POFA and PFA replacement in cement was affected and changed by replacing percent finesse and physical and chemical properties, the pozzolanic activity of these wastes. The Author used waste material replacement 50% instead of Ordinary Portland Cement (OPC). This in turn, will be useful for promoting better quality of construction and innovative systems in the construction industry, especially in Malaysia. This paper is surely one step forward to achieve quality products with affordable, durability and environmental friendly. Disposing of ash contributes the shortage of landfill space in Malaysia. Hence, it will cause a limited visual of environment. Besides, the hazard of ash might be one of the other serious issues, and consequently for human health. The ash disposal area also might create a new problem, which is sedimentation and erosion of the area.

Keywords: Concrete, POFA, PFA, Waste Materials.

1. INTRODUCTION:

Portland cement clinker leads to the emission of CO2. . Each ton of Portland cement produces about 850 kg of CO2 emitted into the atmosphere, therefore causing the greenhouse effect. Thus, it is essential to reduce the production of Portland cement clinker. To find a solution for this problem, it is proposed that the partial replacement of Portland cement with a pozzolanic materials. Mineral additives pozzolans such as fly ash, rice husk ash, palm oil fuel ash and etc., are used as cement replacement. These materials have been reported to increase the stability of the paste, mortar and concrete (Abdullah, Hussin, Zakaria, Muhamad and Abdul Hamid, 2006; Awal and Hussin, 1997; Bamaga, Ismail, Lee and Budiea, 2010). Malaysia is ranked as the world's largest producer of palm oil, give a report for 52% of the total world oils and the industry is the main agricultural industry in the country (Sumathi, Chai and Mohamed, 2008). In 2006, Malaysia recorded production of approximately 15 million tons of crude palm oil (M.P.O.B., 2006). A comprehensive research had been carried out in the past on the use of POFA, PFA, blast furnace slag, rice husk ash etc as

------------------------- ---------------------------------------

* Corresponding author: Email: mntaha2@live.utm.my

** Presenter: Email: smostafa4@live.utm.my

cement replacement material in concrete (A. Abdul Awal, 1998; Hossain, Ahmed and Lachemi, 2011; Khairunisa, 2009; Noor Ahmed, 2007; Sumadi, 1993).

These materials can also improve the durability of concrete. Levels of Portland cements replacement containing with POFA, vary significantly with contents of more than 30% by weight commonly in some regions especially in Malaysia (A. Abdul Awal, 1998; Hossain et al., 2011; Khairunisa, 2009; Sumadi, 1993). The POFA which is used in this study have same properties as standard ASTM C 618-05 because POFA don't have any standard specification until yet in Malaysia, but (ASTMC618–05, 2005) is specified for the use of Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolans, in concrete. Anyway, the use of by-products in building materials is not only controlled by suitability of these materials for this purpose but also by the local economy and the competitive position of other building materials within the area. In terms of technology, it may be possible partly replace sand or binding material with by-products if this is accompanied with improving the end products or reducing the production cost.

This experimental study aims to explore the relevance of POFA and PFA as partial replacement of cement in concrete. It makes an attempt to partially replace cement with palm oil fuel ash (POFA) and fly ash (PFA) to produce cement. The main objective of this study is to determine the effect of the incorporation of different percentages of POFA PFA and compressive strength and density of the samples after 28 days. All samples keep in the water tank and the examination of water curing regime under investigation. Moreover, it comes to studying the development of the strength of the samples at 28 days of curing.

2. MATERIALS AND METHODS

Cement: Ordinary Portland Cement (OPC) of Holcim Top Standard Cement brand from Holcim Cement Manufacturing (Malaysia) Sdn Bhd is used during the study. The OPC used complies with the Type I Portland Cement as in ASTM C150 (ASTMC150–05, 2005) and that is same as Malaysian Standard MS 522 (2007).

POFA: Palm oil fuel ash (POFA) used is a by- product obtained from burning of palm oil shell and husk at temperature of 940ºC from a Kahang mill, Kluang Johor, Malaysia. Afterwards, they are ground using a modified Los Angeles abrasion test machine having 8 stainless bars, each of which is 12 mm diameter and 800 mm long in order to acquire finer particles (Hussin and Awal, 1996). The collected POFA were dried in the oven at the temperature of 110 °C ± 5 for 24 h to remove moisture in it before sieved and ground to obtain finer particles. The presence of higher silica content influences the pozzolanic reaction when it reacts with free lime thus creating extra C-S-H gels, which is beneficial to strength development of the POFA concrete. The sum of SiO2 + Fe2O3 + Al2O3 of POFA is 75.37%, which is above 70%, this makes the pozzolanic material to be classified as Class N pozzolan ASTM C618-05. However, the high percentage of LOI and calcium oxide content of more than 5% , a maximum SO3 content of 5% and a maximum alkali content (expressed as Na2O) of 1.5%, of this ash makes it to fall into class F but not class C, as enlisted in ASTM C618-05. Obviously, this finding also conforms to the observations made by (A. S. M. Abdul Awal and Warid Hussin, 2011).

PFA: Pulverized fuel Ash (PFA) used for this research was obtained from the silos of Kapar Power Station, located Selangor, Malaysia. The oxides analysis (silica, alumina and iron oxide) content is approximately 83.7% of total composition. The content of CaO is less than 10% thus the PFA used during this study is of class F. The fineness of PFA complies with the specifications of ASTM C 618-05 (2005).

Sand (Aggregate gradation): The sand used during this investigation was 50% passed from 600 micron sieved and 30% passed from 1.18 mm sieved and 20% passed from 2.36mm sieved.

Water: In this experimental tap water is used for the manufacture of the mortar.

Superplasticizer: The superplasticizer use during this study was trade name SIKAMENT NN as chemical admixture. According to (ASTMC494/C494M–05, 2005) that is type F high range water reducing admixture. It is from group Sulphonated Naphthalene Formaldehyde condensates (SNF) in dry powder form.

Table 1: Chemical analysis of Cement, POFA and PFA

Chemical compositions %	OPC	POFA	PFA
SiO2	20.10	62.60	59
K2O	0.18	9.05	0.90
Fe2O3	2.40	8.12	3.70
CaO	65.00	5.7	6.90
Al2O3	4.9	4.65	21
P2O5	0.1248	3.86	- -
MgO	3.10	3.50	1.40
SO3	2.30	3.16	1
Cl	0.0005	0.45	- -
TiO2	- -	0.41	- -
Na2O	0.75	0.76	- -
LOI	2.00	6.25	4.62
SiO2 + Fe2O3 + Al2O3	- -	75.37	83.7

3. SPECIMEN PREPARATION AND TESTING:

In all eleven batches including one control batch, each containing 3 cubes of standard size 100x100x100 mm are cast and tested. Mix ratio 1: 2.5 (binder: sand) is considered as basic mix proportion. Over all cement replacement is adopted for all the mixes. The cement replacement is adjusted between POFA and PFA by varying their proportions accordingly. One batch of control specimen without cement replacement is also cast to compare the values. The detail of batches and mix proportion is presented in Table II. Based on the previous research conducted at UTM, Malaysia and with the subsequent modifications made through trial mix series, the value of water/dry mix ratio is fixed at 0.45 throughout the study while the dosage of the superplasticizer is fixed at 0.6 % by weight of the binder. All the weighed constituents were mixed in a mixer for about 4 min to achieve the uniform mix and then poured in the specimen to fill the specimen. After 24 hours the specimens were demoulded and were placed in water tank for 28 days and apply for water curing regime accordingly.

The specimens were removed from the curing regime approximately three hour before testing. Before applying the test of compressive strength all the specimens were weighed to determine the density of the product at the time of the testing. Compression testing machines 1300 KN capacity to test cylinders up to dia. 160x320 mm and cubes up to 150 mm side. Testing machine available in the materials and structures laboratory UTM, Malaysia was used to conduct the test of compressive strength as per the specifications of EN679-2005 and ASTM C 39. For each test a set of 3 specimens was tested and the average of three is calculated nearest to the one digit after decimal.

Table 2: Detail of the mix proportion

Number of batch	Mix proportion	Cement %	POFA %	PFA %	Compressive strength (Mpa)
Control Sample	1: 2.5	100	0	0	39.83
30% POFA & 5 % PFA	1 : 2.5	65	30	5	36.34
30% POFA & 10% PFA	1 : 2.5	60	30	10	31.8
30% POFA & 15% PFA	1 : 2.5	55	30	15	25.62
30% POFA & 20% PFA	1 : 2.5	50	30	20	28.29
30% POFA & 25% PFA	1 : 2.5	45	30	25	21.82
30% POFA & 30% PFA	1 : 2.5	40	30	30	21.6
30% POFA & 35% PFA	1 : 2.5	35	30	35	21.35
30% POFA & 40% PFA	1 : 2.5	30	30	40	20.63
30% POFA & 45% PFA	1 : 2.5	25	30	45	19.4
30% POFA & 50% PFA	1 : 2.5	20	30	50	18.65

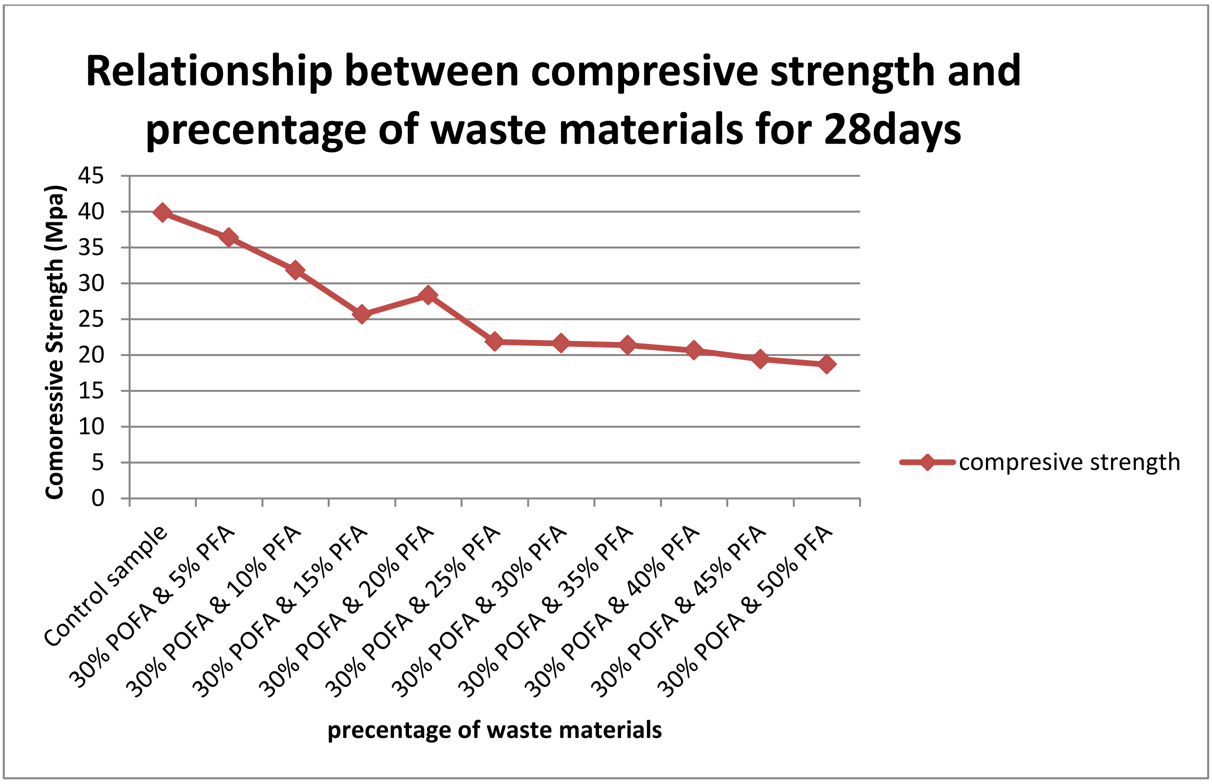

Figure 1: Compressive strength in Water curing regime

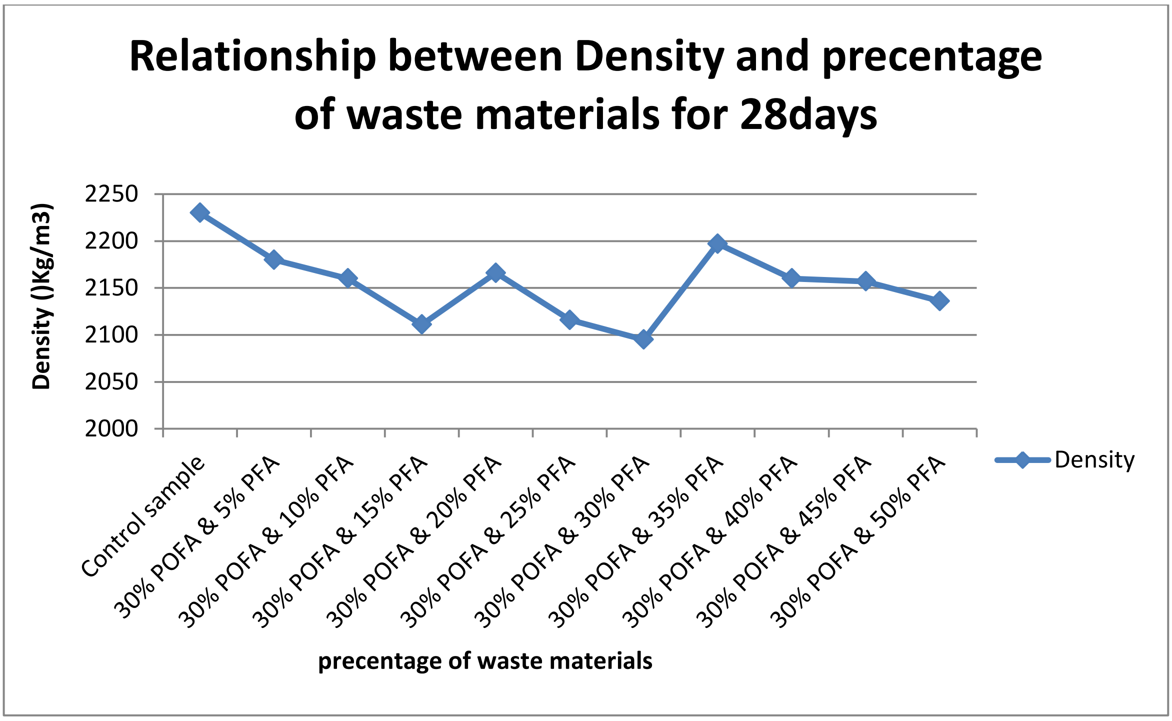

Figure2: Density in Water curing regime

4. RESULTS AND DISCUSSION

Table 2 summarizes the compressive strength results of the specimen tested at different percent of waste materials. Regarding the compressive strength it can be observed from the table that the compressive strength increases with the partial replacement of cement with POFA and PFA except in case of control sample when cement is replaced by 30% and 20% with POFA and PFA, respectively. The maximum compressive strength is achieved when 30% of POFA and 5% of PFA was used as cement replacement in this sample and the compressive strength achieved is 36.34 MPa whereas the compressive strength was optimum when POFA 30% and PFA 20% and the compressive strength achieved is 28.29 MPa which is the optimum when cement is replaced partially with the combination of POFA and PFA (30% and 20%). The further increase PFA content causes the decrease in the compressive strength. However the cement replacement with POFA up to 30% could be considered as the most appropriate in terms of compressive strength.

Table I, it is apparent that the compressive strength of the specimens cured in water for 28 days exhibited better performance because, the water cured specimens have enough water to continue the hydration process thus producing more C-S-H gel which leads to the higher strength. Hence it can be deduced that the water curing of normal concrete causes the increase in compressive strength.

The lowest density is achieved in case of POFA 30% and PFA 30% cement replacement. It is also apparent from the table that the specimens cured in the water showed more density because specimens become saturated and causing the production of more C-S-H gel which also contributes to the increase in the density.

5. CONCLUSION

During the scope of this experimental investigation, it can be conclude that:

Improvement in compressive strength of waste materials mortar is achieved with the incorporation of POFA and PFA as cement replacement. The optimum compressive strength of mortar achieved by using 30% POFA and 20% PFA as partite cement replacement. The density of all mix proportions remained below the control sample.

6. ACKNOWLEDGMENTS

The authors would like to acknowledge Universiti Teknologi Malaysia for the research financial support.

REFERENCES

Abdul Awal, A. S. M., and Warid Hussin, M. (2011). Effect of Palm Oil Fuel Ash in Controlling Heat of Hydration of Concrete. Procedia Engineering, 14(0), 2650-2657. doi: 10.1016/j.proeng.2011.07.333

Abdul Awal, ASM. (1998). A study of strength and durability performances of concrete containing Palm oil fuel ash. (Doctor of Philosophy (Civil Engineering)), Universiti Teknologi Malaysia, PhD Thesis

Abdullah, K., Hussin, M . W, Zakaria, F., Muhamad, R., and Abdul Hamid, Z. (2006). POFA: A potential partial cement replacement material in aerated concrete. Paper presented at the Proceedings of the 6th Asia-Pacific Structural Engineering and Construction Conference (APSEC 2006), Kuala Lumpur, Malaysia.

ASTMC150–05. (2005). Standard Specification for Portland Cement American Society for Testing and Materials (Vol. ASTM C 150 – 05). Philadelphia.

ASTMC494/C494M–05. (2005). Standard Specification for Chemical Admixtures for Concrete American Society for Testing and Materials (Vol. ASTM C 494/C 494M – 05). Philadelphia

ASTMC618–05. (2005). Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete American Society for Testing and Materials (Vol. ASTM C 618 – 05). Philadelphia.

Awal, A., and Hussin, MW. (1997). Effect of palm oil fuel ash on durability of concrete. Paper presented at the Proceedings of the 5th International Conference on Concrete Engineering and Technology, Kuala Lumpur, Malaysia.

Bamaga, Saleh, Ismail, Mohamed A., Lee, Han-Seung, and Budiea, A. M. A. (2010). Effect of Incorporation of Waste Ash on the Behavior of Concrete and Mortar. International Journal of Sustainable Building Technology and Urban Development, 1(1), 74-79. doi: 10.5390/susb.2010.1.1.074

Hossain, K. M. A., Ahmed, S., and Lachemi, M. (2011). Lightweight concrete incorporating pumice based blended cement and aggregate: Mechanical and durability characteristics. Construction and Building Materials, 25(3), 1186-1195. doi: http://dx.doi.org/10.1016/j.conbuildmat.2010.09.036

Hussin, M.W., and Awal, A. (1996). Influence of palm oil fuel ash on strength and durability of concrete. Paper presented at the Proceedings of the 7th International Conference on Durability of Building Materials and Component, Stockholm.

Khairunisa, M. (2009). Properties of palm oil fuel ash cement based aerated concrete. (Doctor of Philosophy (Civil Engineering)), Universiti Teknologi Malaysia, PhD Thesis

M.P.O.B. (2006). Overview of the Malaysian palm oil board industry 2005.

Noor Ahmed, M. (2007). CHARACTERISTICS OF FERROCEMENT ENCASED AERATED CONCRETE SANDWICH WALL ELEMENTS. (Doctor of Philosophy (Civil Engineering)), Universiti Teknologi Malaysia, PhD Thesis

Sumadi, S.R. (1993). RELATIONSHIPS BETWEEN ENGINEERING PROPERTIES AND MICROSTRUCTURAL CHARACTERISTICS OF MORTAR CONTAINING AGRICULTURAL ASH. (Doctor of Philosophy (Civil Engineering)), Universiti Teknologi Malaysia, PhD Thesis

Sumathi, S., Chai, SP, and Mohamed, AR. (2008). Utilization of oil palm as a source of renewable energy in Malaysia. Renewable and Sustainable Energy Reviews, 12(9), 2404-2421.