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Research Article

Properties of sand cement brick containing ground palm oil fuel ash as fine aggregate replacement

Khairunisa Muthusamy [a,*], Muhammad Azreen Ibrahim [a], Nor Hazurina Othman [b], Ahmed Mokhtar Albshir Budiea [c], Saffuan Wan Ahmad [a]

[a] *Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan, Malaysia*
[b] *Faculty of Civil and Environmental Engineering, Universiti Tun Hussien Onn Malaysia, 86400 Parit Raja, Batu Pahat, Malaysia*
[c] *Perunding Teknik Padu, Lot 192-B, Wisma Qistina, Pusat Perniagaan Bandar Baru Beris Kubur Besar, Bachok, Malaysia*

ABSTRACT

The prosperous palm oil industry continues to generate increasing amount of palm oil fuel ash which disposed as environmental polluting waste. Thus, research was conducted to investigate the effect of ground palm oil fuel ash as partial fine aggregate replacement towards properties of sand cement brick. Series of mixes were prepared with 0%, 5%, 10%, 15%, 20% and 25% ground palm oil fuel ash partially substituting the river sand. Two types of curing methods were applied namely water and air curing. The bricks were subjected to compressive strength, flexural strength and water absorption test at 28 days. The results show that utilization of 15% ground palm oil fuel ash as fine aggregate replacement increases the brick strength. The pozzolanic reaction and filler effect of the finely ground ash makes the concrete internal structure denser resulting in strength enhancement. The use of ground palm oil fuel ash in brick production would reduce amount of palm oil waste disposed, save the use of land for dumping purpose and decrease quantity of river sand mined.

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1. Introduction

In Malaysia, both construction trade and palm oil industry contribute to the development of the country. The increasing population calls for more construction of facilities. Sand cement brick is one of the materials which widely used in building construction. The increasing brick production also raises the sand mined from the river. Extreme river sand mining tends to destroy the river vegetation and disturbs the habitats of fauna. Finally if the situation continues, it causes reduction of the aquatic life population threatened to extinction. The adverse effect of river sand mining towards the environment and topographical of river is pointed out by previous researchers, Sathiparan and De Zoysa (2018). Thus, exploration of alternative material to be used as fine aggregate replacement is one of solution to reduce high dependency on natural river sand supply. Converting the available local waste material to be used as fine aggregate for construction material production would be benefitting the environment and community surrounding.

At the same time, palm oil industry which continuously expanding generates plentiful waste over the year. The industry which begins with a small commercial plantation in Kuala Selangor in 1917 has flourished immensely reaching to a total of 5.81 million hectares plantation area all over the country in 2017 (Khusairi et al, 2018). Along with the increasing production of palm oil, this industry also generates a large amount of by-product which disposed as environmental polluting waste. One of the wastes is palm oil fuel ash (POFA), a light ash particles formed during the combustion of palm oil fibre, empty fruit bunch and shell for energy generation at the mill. In practice, this waste is thrown at allocated dumping site within the palm oil mill area and it pollutes the environment. The environmental pollution due to dumping of this waste was highlighted by previous researchers Aprianti (2017) and Muthusamy et al (2018). Continuous

* *Corresponding author*. E-mail address: khairunisa@ump.edu.my (K. Muthusamy)
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disposal of this material would lead to accumulation of the waste consuming larger dumping area and more pollution which is unhealthy for surrounding community.

Realizing the need for cleaner and sustainable environment, many researchers namely Awal and Hussin (1997), Chinaprasirt et al. (2007), Ismail et al. (2010), Zeyad et al. (2013), Megat Johari et al. (2012), Awal and Shehu (2015), Muthusamy et al. (2015), Ul Islam et al. (2016), Salami et al. (2018) Al Subari et al (2018) successfully integrated POFA as partial cement replacement owing to its pozzolanic properties and produces concrete with enhanced properties. There are few researchers Mat Yahaya et al (2016), Wan Ahmad et al (2017) used POFA as fine aggregate replacement in concrete production. However, very limited research is available on the performance of sand cement brick produced using POFA as mixing ingredient. Thus, the present study investigates the effect of ground POFA as partial fine aggregate replacement on properties of sand cement brick.

2. Experimental Details

The brick composition mainly consists of three types of materials namely cement, water and local river sand. Ordinary Portland cement (OPC) from a single source was used throughout the experimental work. Tap water was used for mixing and curing purposes. Palm oil fuel ash (POFA) was obtained from a palm oil mill located in East Coast of Peninsula Malaysia. POFA was collected from an open dumping area at mill as illustrated in Fig. 1. Then, it was oven dried for 24 hours. After ensuring the ash is free from foreign particles, it was ground to be fine to enhance it pozzolanic effect before keeping it in a closed container.

Fig. 1. Palm oil fuel ash disposal space at the mill.

Six types of brick mixes with the dimension size of 210 x 100 x 65 mm were prepared. The control brick specimen was prepared with 0% palm oil fuel ash (POFA). The rest four mixes of brick were prepared by replacing the percentages of POFA from 5%, 10%, 15%, 20%, and 25% by the weight of the sand. The brick mixing work were conducted using a mixing machine to ensure a uniform mix. Then, it is filled in the mould, compacted and left overnight before demoulded the next day. All specimens were subjected to air curing as shown in Fig. 2. All of the specimens were tested for compressive strength, flexural strength and water absorption test. All tests were conducted in accordance to ASTM C55 (2017).

Fig. 2. Sand cement bricks subjected to air curing.

3. Results and Discussion

3.1. Compressive and flexural strength

Figs. 3 and 4 show the compressive strength and flexural strength result of specimens subjected to different curing. The strength performance of all specimens continues to increase as the curing age become longer. This is attributed to the high humidity condition of the tropical weather which allows extended time for water retention in the brick in contrast to exposure in dry weather which would speed up water evaporation. The moist condition enables the occurrence of chemical reaction for C-S-H gel production which is vital for strength enhancement of the brick. Similar observation has been reported by previous researcher Shafigh et al. (2013) who used other types of pozzolanic material as mineral admixture in lightweight concrete. Looking at the effect of ash content, it is observed that replacement up to 20% POFA successfully enhances the brick strength. However, the highest strength performing brick is the one produced with 15% POFA. Generally, strength of the specimens increases due to the pozzolanic reaction and the ability of fine ground POFA to fill the voids inside the specimen making it more compact and stronger. However incorporation of 25% POFA causes reduction in the brick strength. The use of POFA in higher amount reduces the workability of mix and makes it difficult to be compacted which produces brick with higher number of voids and lower strength. Conclusively, the use of ground palm oil fuel ash at suitable percentage improves the strength of sand cement brick.

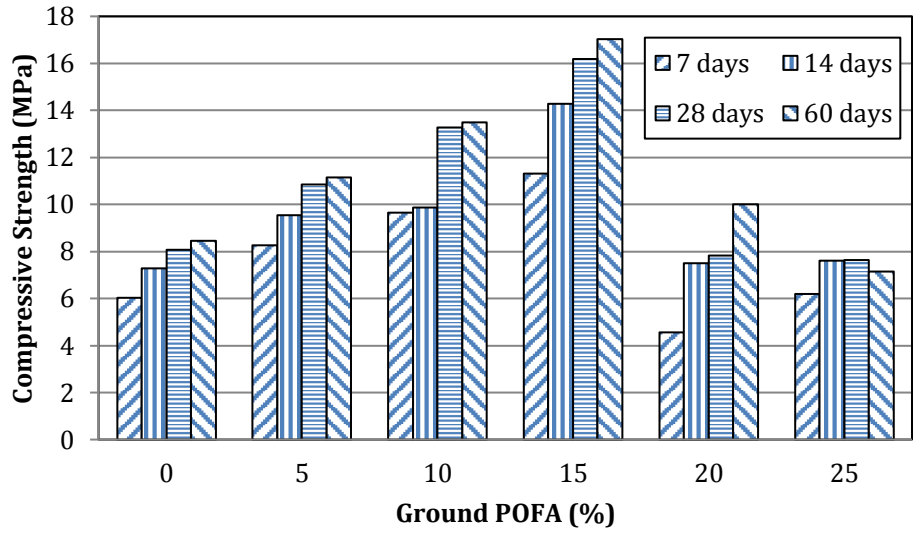

Fig. 3. Compressive strength results of brick with ground POFA content up to 60 days.

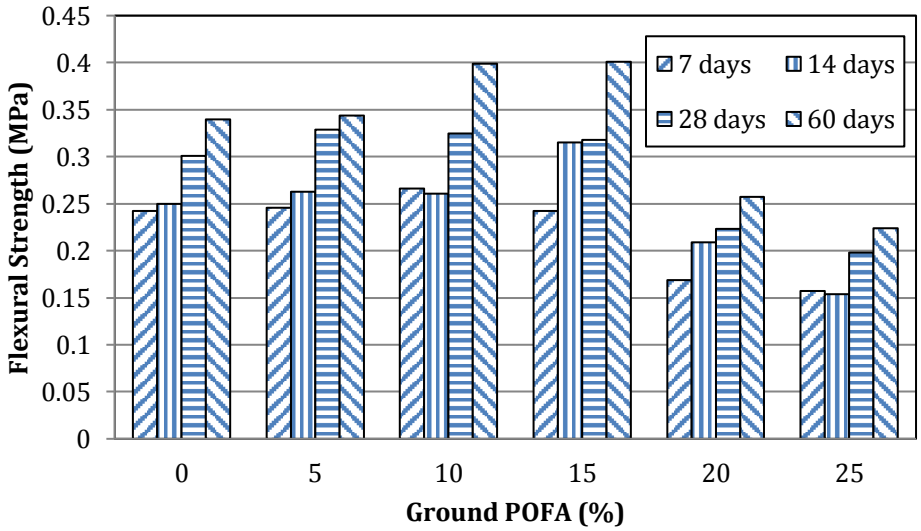

Fig. 4. Flexural strength result of brick with ground POFA content up to 60 days.

3.2. Water absorption

Fig. 5 illustrates the water absorption of brick containing various ground POFA content. Evidently, use of POFA affects the water absorption of the brick. The water absorption of the bricks reduces when POFA is integrated up to 15%. This is believed to be due to the function of the ground ash in forming a denser internal structure of the brick. The positive role of fine POFA in terms of voids filling capability has been pointed by previous researcher Abdul Awal, (1998). However, use of higher content of POFA of 20 and 25% dramatically increases the water absorption. Therefore, it is recommended that the use of POFA as fine aggregate replacement in sand cement brick should be limited not more that 15%.

4. Conclusions

The following conclusions can be drawn from the results:

- With regard to compressive strength and flexural strength, water cured brick containing 15% ground palm oil fuel ash as partial fine aggregate replacement recorded the highest strength of all specimens.
- Utilization of ground POFA up to 15% contribute in reduction of the brick water absorption percentage.
- The thermal conductivity and fire resistance performance of sand cement brick containing ground POFA is among the properties that remains to be explored in future research.
- The present research founds that ground POFA could be a prospective material as a partial sand replacement material for sand cement brick production.

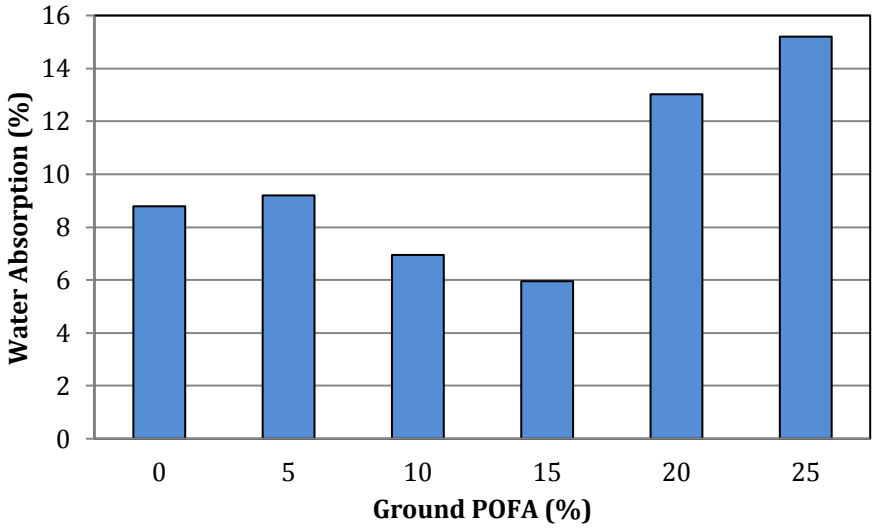

Fig. 5. Water absorption result with ground POFA content at 28 days.

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