Incorporation of Palm Kernel Shell into Fired Clay Brick

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Abstract. Palm oil processing has produce agricultural waste and one of the wastes is palm kernel shell (PKS) which is abundance and creating disposal problems in landfill. Recently, many researchers investigate the incorporation of palm oil waste such as palm fiber, palm oil fuel ash and empty fruit bunch which could have potential as a second raw material in brick manufacture. Therefore, this study is to investigate the physical and mechanical properties of PKS as clay replacement in fired clay brick. Different percentages of PKS (0%, 1%, 5% and 10%) were incorporated into fired clay brick. Manufactured bricks were fired at 1050°C with heating rate of 1°C/min and were tested with dry density, shrinkage, initial rate of suction, water absorption, porosity and compressive strength. XRF result shows that both clay soil and PKS have a highest percentage of Silicon Dioxide (SiO_2) and Iron Oxide (Fe_2O_3). Throughout this study, PKSB1% shows the best result compared to others brick with several improvements on physical and mechanical properties. As the conclusion, PKS could be a potential waste to be utilized as it produces adequate brick with better strength and complied with the requirement.

1 Introduction

Production of palm oil assists Malaysia in terms of economical and also agricultural industry. However, the increased in palm cultivation has led to thousands of tonnes of palm oil waste in Malaysia. Milling process of fresh fruit bunch has produced abundant of palm oil waste such as palm kernel shell (PKS). By sending those agricultural wastes to landfills and disposed through incineration method is not the practical solution because those wastes will release high methane gas during incineration process that caused several environmental problems.

Numerous of researchers had studied incorporation of different types of waste into fired clay brick as an alternative method on maximize the utilization waste product in construction material [1–3]. Furthermore, recycle and reuse of waste product is a worthwhile activity with many beneficial effects to environment and construction field. Based on previous studies, incorporation of waste products into fired clay brick is generously showing the good agreement with others. Therefore, the aim of this study is to

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investigate the possible use of PKS into fired clay brick and its effect on the physical and mechanical effect as it gives positive impact to the environment.

2 Materials and methods

In order to measure the properties of manufactured brick, the materials and methods were discussed in this section.

2.1 Materials

The materials used in this study are PKS and raw clay soil. Upon delivery, raw clay soil and PKS was oven dried for 24 hours at 105°C and then was stored in closed containers. This process is needed in order to ensure that the samples are in dry condition before manufacturing process. The PKS collected from local palm oil mill was ground and sieved passed through 4.75mm sieve to obtain homogenous size.

2.2 Methods

2.2.1 Testing methods for raw clay soils and palm kernel shell

Characterization of chemical composition was tested by using X-ray Fluorescence (XRF) method.

2.2.2 Manufacturing process of control brick and palm kernel shell brick

Once the raw materials have been characterized, raw clay soil was mixed with different percentage of PKS (1%, 5%, and 10%). Necessary amount of water was added to achieve desired consistency of the samples. The mixture then was pressed into mould of 215mm x 115mm x 65mm with pressure of 3000psi. Manufactured samples were oven dried at 105°C for 24 hours and then continued with firing process in furnace at 1050°C using heating rate of 1˚C/min. Control brick also was manufactured for control purposed. The manufactured bricks were designed as Control Brick (CB) for the brick without PKS, and PKSB1%, PKSB5% and PKSB10% for the brick with 1%, 5% and 10% of PKS, respectively.

2.2.3 Physical and mechanical properties of manufactured brick

Physical and mechanical properties of fired clay brick were tested such as dry density, shrinkage, initial rate of suction (IRS), water absorption, porosity and compressive strength that has been conducted at laboratory. All the test were carried out according to British Standards and the results are reported in three mean values [4].

3 Results and discussion

3.1 Characterization of manufactured brick

Chemical analysis of raw clay soil and palm kernel shell was carried out to determine the main component of the materials used in this study. The main oxides present in raw clay soil are SiO_2 (55.7%), Al_2O_3 (24.4%) and Fe_2O_3 (4.46%). Meanwhile, other major components observed in palm kernel shell are SiO_2 (22.58%) and Fe_2O_3 (34.37%).

3.2 Physical and mechanical properties

This study is focusing on the different percentages of palm fibre waste to be incorporated into fired clay brick in order to achieve desired performance on physical and mechanical properties.

3.2.1 Dry density

Dry density of the manufactured bricks is presented in Fig. 1 where the values were varied between 1646.93kg/m^3 to 1915.91kg/m^3 depending on the percentage of waste content. Based on the Fig. 1, CB gives the highest number of dry density which was 1915.9kg/m^3 and followed by PKSB1% and PKSB5% with dry density 1844.6kg/m^3 and 1761.5kg/m^3. The lowest density of brick was obtained with the incorporation with 10% of PKS (1646.9kg/m^3). From the results, all the manufactured brick are classified as high gross densities brick as their densities are over than 1000kg/m^3 [5]. Lower density of brick is highly recommended since it could reduce load during construction work besides reduce logistic costs [6–8].

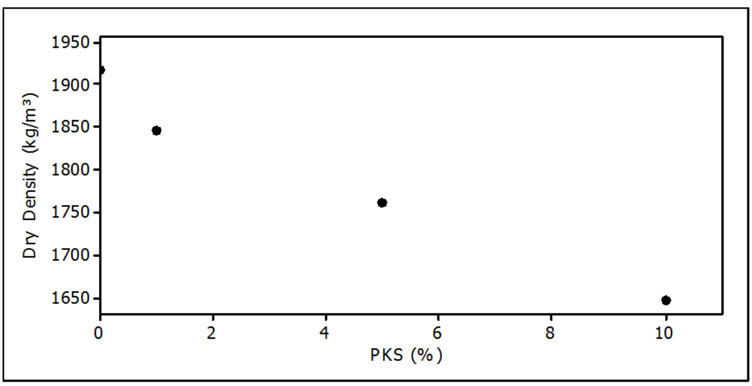

Fig. 1. Dry density of brick.

3.2.2 Shrinkage

Total shrinkage of the manufactured bricks is presented in Fig. 2 where total shrinkage values of the samples were varied within 0.75% to 1.75% depending on the percentage of waste content. As the PKS increased, the value of shrinkage also increased. The lowest was obtained by CB with 0.75%. The result also found that total shrinkage increased with 0.93% (PKSB1%), 1.43% (PKSB5%) and 1.75% (PKSB10%). The requirement has recommended that shrinkage falls within 2.5% to 10% [5]. Unexpectedly the results for all manufactured brick are in good agreement with the requirement.

3.2.3 Initial rate of suction

Initial rate of suction of the manufactured bricks is presented in Fig. 3 where initial rates of suction values of the samples were varied between 2.48kg/m^2.min to 5.61kg/m^2.min depending on the percentage of waste content. As the PKS content increased, the value of initial rate of suction also increased. Based on the result, PKSB10% achieved maximum initial rate of suction which was 5.61kg/m^2.min followed by PKSB5% and PKSB1% which was 3.50kg/m^2.min and 3.29kg/m^2.min respectively. Meanwhile, initial rate of suction for CB was 2.48kg/m^2.min that makes CB obtained the lowest rate among the rest of the brick. However, all manufactured brick shows high initial rate of suction which is over than 2kg/m^2.min. Therefore, brick should be wetted prior 3 hours to 24 hours before laid as suggested by [9].

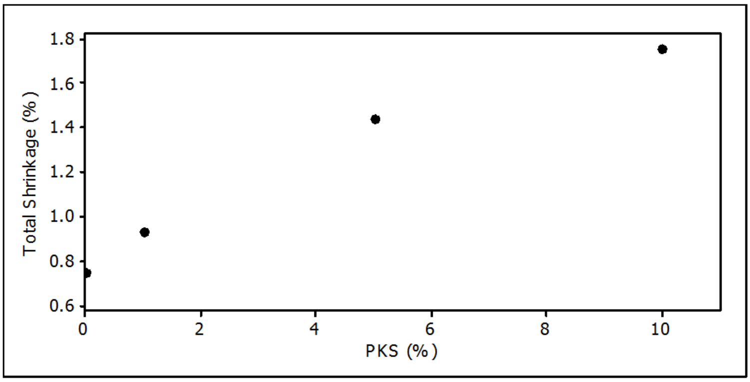

Fig. 2. Total shrinkage of brick.

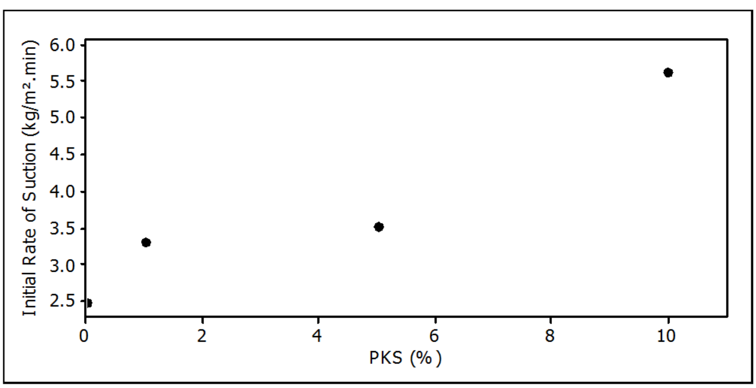

Fig. 3. Initial rate of suction of brick.

3.2.4 Water absorption

Water absorption of the manufactured brick is presented in Fig. 4 where water absorption values of the samples were varied within 12.84% to 17.75% depending on the percentage of waste content. As the PKS content increased, the value of water absorption also increased. Based on the result, CB tends to absorb lowest water absorption with 12.84% compared to others PKSBs. The results also found that increasing 1% to 10% of PKS had increased water absorption of brick with 14.62%, 17.09% and 17.75% respectively. The justification of this behaviour could be related to the organic matter in PKS which eliminate during sintering process thus created numerous pores. According to [4], water absorption of manufactured brick can be classified as Engineering Brick B and brick for Damp Proof Course 2 which only applicable for non-loading application.

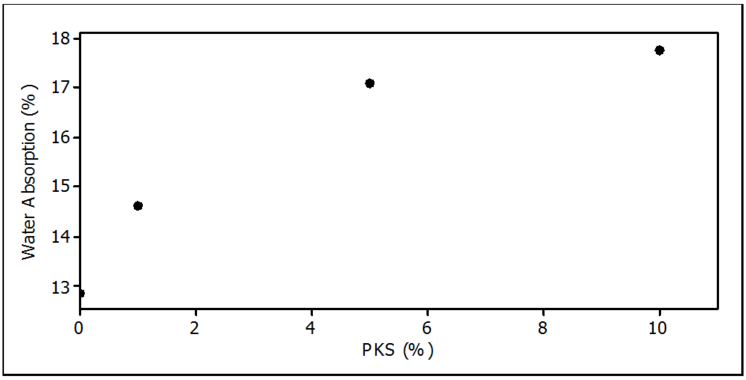

Fig. 4. Water absorption of brick.

3.2.5 Porosity

Porosity of the manufactured bricks is presented in Fig. 5 where porosity values of the samples were varied between 14.65% to 21.35%, depending on the percentage of waste content. Based on the figure, PKSB10% gives the highest porosity (21.34%) followed by PKSB5% and PKSB1% with 17.72% and 16.32% respectively. Meanwhile, CB was obtained lowest porosity with 14.65%. It was acclaimed that high porosity could reduce thermal conductivity of brick as well as beneficial for higher energy saving in building application [10-11].

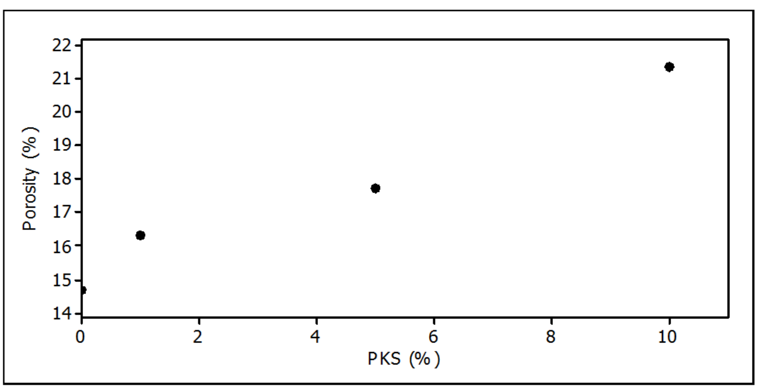

Fig. 5. Porosity of brick.

3.2.6 Compressive strength

Compressive strength of the manufactured bricks is presented in Fig. 6 where compressive strength values of the samples were varied between 6.75MPa to 19.52MPa depending on the percentage of waste content. As the PKS content increased, the value of compressive strength is decreased. From the figure, PKSB1% obtained the highest compressive strength with 24.61% followed by others PKSB with 12.50MPa (PKSB5%) and 6.75MPa (PKSB10%). Meanwhile, compressive strength for CB was recorded as 19.52MPa. It is expected that PKSB10% contained high organic matter thus leaves numerous pores during sintering process which is lead to reduce the strength of brick. According to [4], all the brick were above the minimum requirement and be applied for non loading construction application.

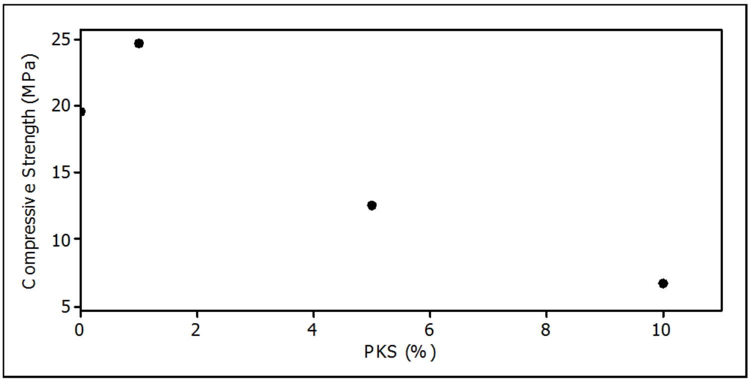

Fig. 6. Compressive strength of brick.

4 Conclusions

PKS can be regarded as a potential addition to raw materials used in the manufacturing of fired clay brick. Incorporation of clayey soil and PKS can be used as building material with acceptable physical and mechanical properties match with the requirement of non-loading application. It was suggested that incorporation of 1% of PKS into fired clay brick could be an alternative method to reduce abundant PKS waste in landfill. Mixing 1% of PKS is recommended as it produced highest compressive strength and lower in density, which are desirable in producing green building product.

The results presented in this paper are part of an ongoing postgraduate research. The authors would like to thank the Faculty of Civil Engineering, UTHM for this study.

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