PHYSICAL, MECHANICAL AND ENVIRONMENTAL PROPERTIES OF FIRED CLAY BRICKS INCORPORATED WITH PALM OIL MILL WASTE

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Specially dedicated to my life companion Mohd Anuar bin Yahya, my beloved parents Mr Sarani bin Mansur and Mrs Salbiah bt Mat, in-law Mr Yahya bin Ahmad and Mrs Roslee bt Agil and family

For their love, endless support, encouragement and sacrifices

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ABSTRACT

The growth of the oil palm industry in Malaysia has generated a significant amount of palm oil mill waste (POMW) causing waste disposal problems. Due to operational challenges and expensive operational cost, POMW is potentially incorporated into fired clay brick owing to high lignocellulosic characteristics. Therefore, this study aims to investigate the physical, mechanical and environmental properties of POMW such as palm kernel shell (PKS), palm oil fuel ash (POFA), palm fibre (PF) and empty fruit bunch (EFB) as a replacement material for brick making. In this study, bricks were manufactured with 0, 1, 5 and 10% of POMW and fired at 1050°C (heating rates at 1, 3 and 5°C/min). The results showed that bricks with 5% of POMW and fired at 1°C/min are significant to reach equilibrium between positive (decrease of weight and increase of porosity) and negative (increase of water absorption and decrease of mechanical resistance) effects. The leaching of Toxicity Characteristic Leaching Procedure (TCLP) and Synthetic Precipitation Leaching Procedure (SPLP) tests revealed that all bricks complied with the United States of Environmental Protection Agency (USEPA) and World Health Organization (WHO) regulation due to the effectiveness of thermal treatment encapsulated heavy metals within the brick matrix by forming lead ferrite, chromia, gahnite and jacobsite. Meanwhile, the incorporation 5% of POMW (1°C/min) into fired clay brick positively contribute to the energy saving from 5.5% to 13.4% due to the embodied energy stored in POMW released during the firing process and thus generates secondary heat input to the furnace. In the meantime, the estimated total emission (ETE) revealed that higher heating rates significantly emit lower gases during firing period. However, lower heating rate (1°C/min) should be considered to attain excellent properties of brick. As a conclusion, incorporation 5% of POMW (1°C/min) is capable of improving better physical and mechanical properties, complies with the environmental standard as well as providing an alternative new disposal method for the wastes as one of the green technology in construction industry as stated in the Government's Eleven Malaysia Plan (RMK-11).

ABSTRAK

Pertumbuhan industri kelapa sawit di Malaysia telah menghasilkan sejumlah besar sisa kelapa sawit (*POMW*) yang menyebabkan masalah pelupusan. Disebabkan oleh cabaran operasi dan kos operasi yang mahal, POMW berpotensi dimasukkan ke dalam bata tanah liat yang dibakar kerana ciri-ciri tinggi lignoselulose. Oleh itu, kajian ini bertujuan untuk mengkaji ciri-ciri fizikal, mekanikal dan alam sekitar *POMW* seperti tempurung kelapa sawit (*PKS*), abu kelapa sawit (*POFA*), gentian sawit (*PF*) dan tandan buah kosong (*EFB*) sebagai bahan ganti untuk membuat bata. Dalam kajian ini, bata dihasilkan dengan 0, 1, 5 dan 10% *POMW* dan dibakar pada 1050°C (kadar pemanasan pada 1, 3 dan 5°C/min). Keputusan menunjukkan bata dengan 5% *POMW* ketara mencapai keseimbangan antara positif (berat menurun dan keliangan meningkat) dan negatif (penyerapan air meningkat dan rintangan mekanikal menurun). Ujian larut lesap prosedur ciri-ciri ketoksikan larut lesap (*TCLP*) dan prosedur pemendapan sintetik larut lesap (*SPLP*) mendedahkan bahawa semua bata mematuhi peraturan Agensi Perlindungan Alam Sekitar (*USEPA*) dan Pertubuhan Kesihatan Dunia (*WHO*) akibat keberkesanan rawatan termal memerangkap sisa logam di dalam matriks bata dengan membentuk *lead ferrite, chromia, gahnite* dan *jacobsite.* Sementara itu, penggabungan 5% *POMW* (1°C/min) ke dalam bata tanah liat dibakar positifnya menyumbang kepada penjimatan tenaga dari 5.5% hingga 13.4% disebabkan tenaga terkandung yang tersimpan dalam POMW terbebas semasa proses pembakaran dan menghasilkan input haba sekunder kepada relau. Pada masa yang sama, anggaran jumlah pelepasan (*ETE*) mendedahkan bahawa kadar pemanasan tinggi ketara mengeluarkan gas rendah semasa tempoh pembakaran. Walaubagaimanapun, kadar pemanasan rendah (1°C/min) perlu dipertimbangkan untuk mencapai sifat cemerlang bata. Sebagai kesimpulan, penggabungan 5% POMW (1°C/min) mampu meningkatkan sifat fizikal dan mekanikal yang lebih baik, mematuhi kawalan alam sekitar serta menyediakan kaedah alternatif pelupusan baru

untuk sisa sebagai salah satu daripada teknologi hijau dalam industri pembinaan seperti dinyatakan dalam Rancangan Malaysia ke Sebelas (RMK-11).

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