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Thermal Conductivity Of Fired Clay Bricks Incorporated With Cigarette Butts

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Abstract. Billions of cigarette butts (CBs) were discarded by smokers directly into the environment. It is known that CBs are one of the environmental pollution that could caused contamination on the street, sidewalks, waterways, beaches and public areas. Due to its small size but large in volume, CBs cannot be collected easily and most of it will be disposed directly to the landfill. Moreover, there is no easy mechanism to ensure the separation of the chemicals trap inside the CBs which is toxic to the environment. Therefore, by incorporating CBs into brick bodies will be an alternative solution to CBs littering and pollution problems. In this study, different percentages of CBs (0%, 2.5% and 5.0%) were incorporated into fired clay brick. Different heating rates were applied during firing stage which are 1ºC/min, 3ºC/min and 5ºC/min respectively. All samples were fired at 1050ºC. Thermal conductivity for cigarette butt brick (CB Brick) were tested using Hot Guarded Plate Method. From the results obtained, it could be concluded that; with higher percentages of CBs, the thermal conductivity properties were also improved which is desired but most of the brick manufacturers. CBs incorporated could be an alternative pore formers to improve the thermal properties of fired clay brick. At the same time, the porosity is also increased thus the density was significantly reduced to become lightweight brick.

Introduction

Indiscriminate littering of cigarette butts (CBs) can cause serious environmental impact. CBs may be littered directly to the environment or indirectly via runoff water or carried away from streets and sidewalks to storm drains [1]. In fact, cigarette butts are one of the most littered item in the world [2,3]. According to Register [3], 2.1 billion of cigarette butts were discarded worldwide. The impact of CBs littering is not only towards the environment but it is also harmful to the marine life and aquatic life. The chemicals entrapped inside cigarette butts can easily leach out from the butts and cause deadly effect to aquatic life such as water flea, *Daphnia Magna*, which is a small crustacean at the lower end, but important to the aquatic food chain. Furthermore, these cigarette litters have also been found in the stomachs of fish, birds, whales and other marine life that swallowing this poisonous filters, harmful plastic and toxic chemicals [4,5]. Moreover, most cigarette filters are made of cellulose acetate which is slow to biodegrade and can take up to 18 months or more to break down under normal litter conditions, 12 months to break down in freshwater and up to 5 years to break down in seawater.

Commonly, CBs is made from 95% of cellulose acetate. Cellulose acetate is the standard term used to express a variety of acetylated cellulose polymers. Technically, cellulose acetate is biodegradable, however CBs only biodegrade under conditions described as severe biological circumstances [6,7]. CB is about 30% from the cigarette's original length and function to reduce nicotine and tar yield of cigarette during smoking. CB that act as filter in a cigarette have long term effects on the urban environment as it is designed to absorb vapors, accumulate particulate smoke components of cigarette and trapped the toxic chemicals.

Incorporated CBs with clay soil in fired clay brick manufacturing provides new alternative to reduce environmental pollution and disposal method for CBs [8,9,12,11,12]. Furthermore, the processes to recycle CBs is quite difficult because there are no easy mechanisms or procedures to assure efficient and economical separation of the butts and appropriate treatment of the entrapped chemicals. In addition, from previous study, the incorporation of fibrous waste such as of rice husk [13,14,15,16], baggase [15], processed waste tea [17], wheat straw [18], spent grains [19] and tobacco residue [20] mostly improved the thermal properties as the waste could act as pore fore formers additives. Therefore in this study, manufacturing CB Brick could be a practical solution and due to CB fibrous characteristics, it could also be an additive that improve the brick properties especially the thermal conductivity.

Thermal conductivity of materials is varies over a wide range, as it influences the usage of the material in the engineering applications. Thermal conductivity of a brick is the rate at which a brick conducts heat. It can be defined as the quantity of heat transmitted through a unit thickness of materials in direction as a result of temperature difference under steady boundary condition [24]. It also measured the capability of the materials to conduct heat. Every materials store different heat, thus high value of thermal conductivity indicates that the materials is a good heat conductor meanwhile low value indicates that the materials is poor heat conductor or express as insulator.

It is stated by Turgut and Yesilata [21] that heat losses from buildings are dependent on the thermal conductivity of the materials in the walls and roof. Meanwhile, as for by Söylemez [22], good building bricks should minimize the heat flow from one side of the brick to the others. The factors that influences thermal conductivity are density and porosity [18,23]. High porosity materials tends to be highly insulating because of air, which is a very poor thermal conductor trap inside the materials. With this condition, poor thermal conductivity are preferred in industrial applications, which will minimize the energy consumption.

Material and methods

In order to measure the thermal conductivity, porosity and density of using CBs for brick production, the materials and method were discussed in this section.

Preparation of raw materials clay, CBs and water. The soil used was clay soil. Upon delivery, the soil was stored in closed containers and then it was oven dried for 24 hours at 105ºC. After completed drying process, the dried soils immediately transferred to containers, which ready for laboratory test. To ensure there are no impurities in the soil, it was sieved.

Before brickwork started, the soil classification was done accordance with BS 1377 [25]. As for the classification, test of plastic limit (PL) and liquid limit (LL) are important indicators of the soil type. Results of the physical properties of the soils is shown in Table 1.

Manufacturing Process of Clay Bricks. In this study, two types of brick were manufactured; CBs brick and control brick. As for control brick, only clay soil was mixed with suitable amount of water to produce the brick. After the soil was completely mixed, the sample was pressed into mould size of 225 mm x 110 mm x 65 mm. Brick samples were dried at room temperature for 24 hours, followed by oven drying at 105°C for 24 hours. All the brick samples were fired at three different heating rates; 1^{o}C/min, 3^{o}C/min, and 5^{o}C/min. The same method as previously explained were applied in CB brick manufacturing. The only thing that differ is the addition of CBs with 2.5% and 5.0% percentage by weight.

Table 1
Properties of the Soil Used in Making Fired Clay Bricks

Soil Physical Properties	Test Results
Liquid Limit (%)	31.4
Plastic Limit (%)	23.21
Maximum Dry Density (mg/m^3)	1.7
Optimum Moisture Content (%)	17
Soil Classification	Silty Clay or Clayey Silt

Testing method for manufactured brick. The thermal conductivity was tested using hot guarded plate method. This device can measure the thermal conductivity of material when a layer of materials of known thickness and area heated from one side by an output. This test also measured the ability of the materials to conduct heat. This testing was according to BS EN ISO 8990 [26]. The experiment was run for 100 minutes for each sample and the data was recorded every 1 minute. Apparent density and porosity were also measured in this study as thermal conductivty also influenced by these properties.

Results and discussion

Experimental results of the samples fired at 1050°C are given in Table 2. The results obtained revealed that apparent densities decreased steadily with an increased in the amount of CBs. Lowest apparent density achieved is 2.28g/cm^3. In the meantime, apparent porosity was significantly increased with the increasing amount of CBs. The highest porosity recorded was 37%.

The relationship between thermal conductivity, density and apparent porosity can be seen in Table 2. From the results, with the highest percentage of CBs content added, thermal conductivity shows the best improvement of the thermal conductivity properties. By comparing the results at different heating rates, thermal conductivity values improved the most at 5°C/min. Therefore, in this study, the best thermal property is 0.779 W/m.K which were determined when 5% of CBs content fired at 5°C/min heating rates. This study also demonstrates the same results as found by previous study that; as the porosity increased, the density will decreased thus lower effective thermal conductivity performance is obtained [23,28].

Table 2
Experimental results of the brick samples fired at 1050°C

Properties	Heating Rates / Percentage of Cigarette Butts Addition By Weight								
	1°C/min			3°C/min			5°C/min		
	0%	2.5%	5.0%	0%	2.5%	5.0%	0%	2.5%	5.0%
Degree of firing (°C)					1050				
Density (g/cm^3)	2.55	2.38	2.35	2.43	2.37	2.28	2.40	2.37	2.35
Apparent Porosity (%)	28	34	37	31	36	35	31	35	36
Thermal Conductivity, k (W/m.K)	0.964	0.805	0.908	0.912	0.871	0.826	0.880	0.850	0.779

The changes in porosity also were proven by electron micrograph images as illustrated in Fig. 1 and Fig. 2. Observation from Fig. 1 and 2 revealed the significant changes in the growth of pore sizes with the incorporation of 5.0% of CBs compared to control brick fired at 1°C/min of heating rates. This is due to the fibrous nature in CB that burned out during the firing process. These images also corresponded to the decreasing value of density and the improved values of thermal conductivities.

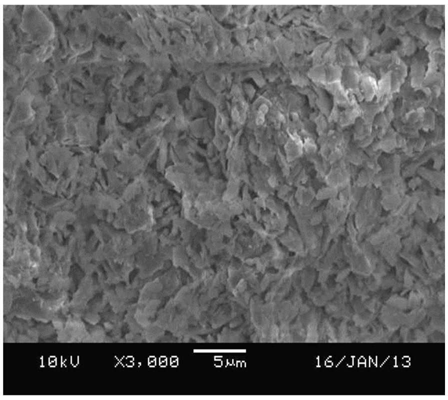

Fig. 1 The electron micrograph images of Control Brick at 3000X magnification

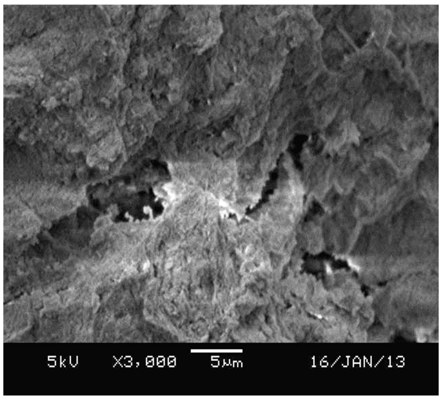

Fig. 2 The electron micrograph images of CB Brick with 5.0% of CBs at 300X magnification

Conclusion

From the results obtained in this study, the best thermal values were obtained at 5.0% of CBs at 5°C/min of heating rates (improved by 10% to 18%) compared to control brick. The results indicated that the CBs could be utilized as pore-forming additives into brick bodies or insulation materials as the CBs content cellulose acetate fibre that could easily burned during the firing process. The effect on the properties paralleled to growth of pores, decreased density and improvement on thermal conductivity of the fired clay brick. Nevertheless, it is recommended that firing the CB Brick at 1°C/min of heating rates with 2.5% CBs yields the optimum performance of all the other properties of the CB brick which will be discussed in a different paper.

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References

[1] T. E. Novotny, K. Lum, E. Smith, V. Wang, R. Barnes, Cigarettes Butts and the Case for an Environmental Policy on Hazardous Cigarette Waste: International Journal of Environmental Research and Public Health, 6 (5) (2009), p. 1691-1705.

[2] Cigarette Litter, For details see: http://www.cigarettelitter.org (accessed 15 Februari 2012).

[3] K. M. Register, Cigarette butts as litter-Toxic as well as ugly: Underwater Naturalist Bulletin of the American Littoral Society, 25 (2) (2000), p. 23-29.

[4] Roe, David, Marine Debris: Killers in Our Ocean: National Parks Journal, 51 (6) (2007).

[5] Butt In to Butt Out, For details see: http://pubs.acs.org/cen/science/85/8544sci2.html (accessed 25 March 2012).

[6] T. Ishigaki, W. Sugano, A. Nakanishi, M. Tateda, M. Ike, M. Fujita, The Degradability of Biodegradable Plastics in Aerobic and Anaerobic Waste Landfill Model Reactors, Chemosphere, 54 (3) (2004), p. 225-233.

[7] A. Ach, Biodegradable Plastics Based on Cellulose Acetate: Journal Macromol Science Pure, 30 (9) (1993), p. 733-740.

[8] A. A. Kadir, A. A. Mohajerani, Physico-Mechanical Properties and Leachate Analysis Of Clay Fired Bricks Incorporated With Cigarette Butts. In: Proceeding of International Conference on Environment. Malaysia: Universiti Sains Malaysia, (2008). p. 15-17.

[9] A. A. Kadir, A. Mohajerani, A Possible Utilization Of Cigarette Butts In Light- Weight Fired Clay Bricks. In: Proceedings World Academy Of Science. Paris, 35 (28) (2008b), p. 153-157.

[10] A. A. Kadir, A. A. Mohajerani, F. Roddick, J. Buckeridge, Density, Strength, Thermal Conductivity and Leachate Characteristics of Light-Weight Fired Clay Bricks Incorporating Cigarette Butts. In: Proceedings of World Academy Of Science, Engineering And Technology. Japan, 53 (170) (2009), p. 1035-1041.

[11] A. A. Kadir, A. A. Mohajerani, Possible Utilization Of Cigarette Butts In Light-Weight Fired Clay Bricks: International Journal of Environmental Science and Engineering, 2 (3) (2010).

[12] A. A. Kadir, A. A. Mohajerani, Recycling Cigarette Butts In Light-Weight Fired Clay Bricks: Journal of Construction Materials. In: Proceedings of the Institution of Civil Engineers, 164 (5) (2011), p. 219-229.

[13] B. E. E. Hegazy, H. A. Fouad, A. M. Hassanain, Brick Manufacturing From Water Treatment Sludge and Rice Husk Ash: Australian Journal of Basic and Applied Sciences, 6 (3) (2012), p. 453-461.

[14] B. I. Ugheoke, E. O. Onche, O. N. Namessan, G. A. Asikpo, Property Optimization of Kaolin-Rice Husk Insulating Fire-Bricks: Leonardo Electronic Journal of Practices and Technologies, 9 (2006), p. 167-178.

[15] P. Lertwattanaruk, J. Choksiriwanna, The Physical and Thermal Properties of Adobe Brick Containing Baggase for Earth Construction: Journal of Architectural/Planning Research and Studies, 5 (1) (2011), p.187-199.

[16] V. Banhidi, L. A. Gomze, Improvement of Insulation Properties of Conventional Brick Products: Materials Sciences, 589 (2008), p. 1-6.

[17] I. Demir, An Investigation on the Production of Construction Brick with Processed Waste Tea: Building and Environment, 41 (2006), p. 1274-1278.

[18] R. Saiah, B. Perrin, L. Rigal, Improvement of Thermal Properties of Fired Clays by Introduction of Vegetable Matter: Journal of Building Physics, 34 (2) (2010), p. 124-142.

[19] S. Krebs, H. Mortel, The Use of Secondary Pore Forming Agents in Brick Production: Tile and Brick International, 15 (1) (1999), p. 12-18.

[20] I. Demir, Effect of Organic Residues Addition on the Technologies Properties of Clay Bricks: Waste Management, 28 (2008), p. 622-627.

[21] P. Turgut, B. Yesilata, Physico-Mechanical and Thermal Performances of Newly Developed Rubber-added Bricks: Energy and Building. 40 (2008), p. 679-688.

[22] M. S. Söylemez, On the Effective Thermal Conductivity of Building Bricks: Building and Environment. 34 (1999), p. 1-5.

[23] M. Dondi, F. Mazzanti, P. Principi, M. Raimondo, G. Zanarini, Thermal Conductivity of Clay Bricks: Journal of Materials in Civil Engineering, 16 (1) (2004).

[24] W. M. Rohsenow, J. P. Hartnett, Y. I. Cho, Handbook of Heat Transfer. McGraw-Hill; 1998.

[25] British Standard Institution (BS 1377) 1990. Methods of Test for Soils for Civil Engineering Purposes. Classification Tests.

[26] British Standard Institution (BS EN ISO 8990) 1996. Thermal Insulation - Determination of Steady- State Thermal Transmission Properties - Calibrated and Guarded Hot Box.

[27] Ghazi, Al-Marahleh, Production of light weight ceramics teils from local materials: American Journal of Applied Sciences 2 (4) (2005), p. 778-783.

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