MICROSTRUCTURE ANALYSES ON THE EFFECT OF INCORPORATING CIGARETTE BUTTS IN FIRED CLAY BRICKS

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Introduction

Worldwide, cigarette butts (CBs) are one of the most common types of litter. The United States Department of Agriculture estimates that in 2004 over 5.5 trillion cigarettes were produced in the world. This is equivalent to an estimated 1.2 million tonnes of CBs waste per year. These figures are expected to increase by more than 50% by 2025, mainly due to an increase in world population [1]. In Australia alone, an estimated 25 to 30 billion filtered cigarettes are smoked each year; of these, an estimated 7 billion are littered.

CBs accumulate in the environment mainly due to the poor biodegradability of the cellulose acetate filters. Filters have long term effects on the urban environment, especially in waterways and run-offs. Toxic chemicals trapped in the CB filters can leach, thus causing serious damage to the environment [2]. Recycling CBs is problematic because there are no easy mechanisms or procedures to assure efficient and economical separation and recycling of the entrapped chemicals. An alternative could be to incorporate CBs in a sustainable composite building material such as fired bricks.

Brick is one of the most accommodating masonry units as a building material due to its properties. Attempts have been made to incorporate waste in the production of bricks; for instance, the use of rubber, limestone dust and wood sawdust, processed waste tea, fly ash, polystyrene and sludge [3]. Recycling of such wastes by incorporating them into building materials is a practical solution to the pollution problem. In addition, adding carbonaceous industrial wastes has also been demonstrated to be an efficient and environmentally advantageous way of reducing fuel use for brick-making. This paper describes some of the procedures and results from a study on incorporating CBs into fired clay bricks. Physical and mechanical properties of several brick samples with different CB contents are presented. The main objective of this paper is to present the microstructure analyses on the effect of incorporating CBs in the fired clay bricks.

Experimental

Materials

The CBs (of different brands and sizes) used in this study were provided by Buttout Australia Pty Ltd. The butts had been collected from dry receptacles. Upon delivery, the CBs were disinfected at 105^{o}C for 24 hours and then stored in sealed plastic bags. The soil used was brown silty clayey sand prepared for making fired clay and provided by Boral Bricks Pty Ltd, Australia.

Apparatus and Procedures

Four different mixes were used for making fired brick samples. CBs (2.5, 5, and 10 % by weight, about 10 to 30% by volume) were mixed with the experimental soil and fired to produce bricks. The mixes were made using a Hobart mechanical mixer with a 10 litre capacity for 5 minutes. The samples were made in three sizes, cube, beam and brick, for determining compressive strength, modulus of rupture, rate of water absorption, total water absorption and the density of the manufactured bricks.

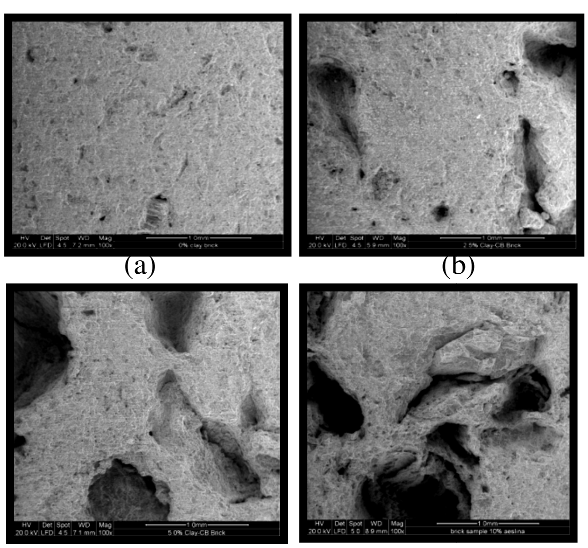
The specimens were dried at 105^{o}C for 24 hours, removed from the moulds and were fired in a (Barnstead/Thermolyne 30400) furnace at 1050^{o}C. The fired samples were tested for compressive strength, flexural strength, density, water absorption and initial rate of absorption. All tests were carried out according to the Australian Standards [4] and the results reported are the mean of three values.

Electron micrograph images of the tested samples were recorded using an Environmental Scanning Electron Microscope (ESEM). Study of these images enabled a better understanding of the morphology of the microstructure, both for the control brick as well as the CB brick.

Results and discussion

The results show that the density of fired bricks decreased by 8.3 to 30% when 2.5 to 10% CBs was incorporated into the raw materials. The compressive strength of bricks tested was reduced from 25.65 MPa (control) to 12.57, 5.22 and 3.00 MPa for 2.5, 5.0 and 10% CB content respectively. Lateral modulus of rupture test results show that the flexural or tensile strength of bricks does not decrease significantly with the incorporation of CBs up to 5% CBs. The lowest value of flexural strength found was 1.24 MPa (for 10 % CBs). Water absorption values were increased from 5 to 18% and the initial rate of absorption results increased from 0.2 to 4.9 kg/m^2/min for the experimental mixes.

Figure 1 shows the effect of incorporating CB in the fired clay bricks on the surface and on the cross-sectional view of the bricks tested. It can be clearly seen, with increasing CB content, the formation of cracks became more visible, resulting in the pores becoming larger in numbers and sizes. These changes were also proven by the electron micrographs images analysed at 100x magnifications using the same brick samples at various levels of CB. In Figure 1 (a) at 100x magnification for control clay brick, few micro-pores were visible. However, observation of Figure 1 (b), (c) and (d) at 100x magnification respectively, revealed the significant changes in the growth of pore sizes as CB content increased from 2.5% to 10% by mass. This corresponded to the reduction in dry density and strength, which resulted in increasing water absorption properties.



(a) (b) (c) (d)

Fig. 1 Electron micrographs images at 100X magnification for different percentages of CBs incorporated into fired clay bricks: (a) 0% CB content (b) 2.5% CB content (c) 5% CB content (d) 10% CB content.

Conclusion

CBs can be regarded as a potential cost effective addition to the raw materials used in the manufacture of light-weight fired bricks. CBs also could act as a pore-forming additives or insulation materials in brick manufacturing due to its cellulose acetate fibre inside the CB. The effect on the properties corresponded to the growth of pores and formation of cracks caused by incorporated CBs in the clay brick, as observed in the ESEM electron micrograph images were also demonstrated on the tested samples. Nevertheless, the results obtained in this study show that all the physical and mechanical properties complied with the Australian Standards [5] except for compressive strength. Despite the reductions on the strength value, the manufactured brick can still be used for non-load-bearing and load-bearing purposes according to AS/NZS 4455.1 (2008) [6].

References

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