RECYCLING OF CLAY BASED DEMOLITION WASTES FOR THE PRODUCTION OF CONCRETE BLOCK

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ABSTRACT

Construction and Demolition (C & D) wastes constitute a major portion of total solid wastes production in the world, and most of them are disposed in land fills. Preservation of the environment and conservation of the rapidly diminishing natural resources be the essence of sustainable development. As such, recycled aggregates are advocated. This paper examines the possibilities of using fired clay bricks (FCB) as coarse aggregates for the manufacturing of new concrete block. The coarse aggregates were replaced with 20 -100% of crushed FCB and strengths of more than 35 N/mm^2 was monitored. Results showed that substituting 40% of clay brick aggregates after 28 days curing produced higher mechanical strength compared to the reference, natural aggregates. Thus opening a new avenue for building and construction industries to have an alternative construction material in future.

Keywords: Recycled aggregates; Fired clay bricks; Concrete; Demolition wastes

INTRODUCTION

Clay based material is one of the materials that has been widely used in construction materials instead of wood, sand, concrete and other waste materials. This material is a major compounds in clay brick, clay tiles and clay roofing tiles due to its wide-ranging properties, high resistance to atmospheric condition, geochemical purity, and easy access to its deposits near the earth's surface and low price (Konta *et al.,* 1995). Fired clay brick (FCB) can be categorized as one of the demolition wastes as most of the unwanted FCB from buildings or houses renovation are being illegally disposed off in most places. The utilization of this type of clay based waste materials would replace the natural aggregates in concrete mixture.

Previous research reported that the utilization of crushed clay bricks have been conducted to study the feasible use of crushed clay brick as unbound road sub-base (Poon *et al.,* 2006). The results showed that replacement of recycled concrete aggregates by crushed clay brick further increased the optimum moisture content and decrease the maximum dry density. In fact, the recycled clay bricks were also used as aggregates in asphalt concrete (Khalaf *et al.,* 2005). These aggregates were made with granite which was of high porosity and roughness on the surfaces of crushed clay brick aggregates.

Monteiro *et al.,* (2003) investigate the effect of ground clay brick to replace cement mass. The ground clay bricks meet the strength activity requirements of ASTM in mortar and effective in suppressing the alkali-silica reaction expansion in mortar. Gutovic *et al.,* (2005) later reported the strength development of autoclaved OPC-clay brick blends, where different varieties of clay-brick were used. The optimum compressive strengths were achieved at 50 mass % clay brick additions. Poon *et al.,* (2006) presented a study on the investigation of blending recycled concrete aggregate and crushed clay brick as aggregates on the production of paving blocks. The results indicated that the incorporation of crushed clay brick reduced the density, compressive strength and tensile strength of the paving blocks. Recently, Kenai *et al.,* (2007) examined the possibility of using crushed brick as coarse and fine aggregate for a new concrete. Results showed that it is possible to manufacture concrete containing crushed bricks (coarse and fine) with characteristics similar to those of natural aggregates concrete provided that the percentage of recycled aggregates is limited to 25% and 50% for the coarse and fine aggregates, respectively.

This study will explore on the potential of using fired clay based demolition wastes as aggregates in construction materials such as concrete.

MATERIALS AND METHODS

Concrete blocks were made of cement, water, coarse and fine aggregates. Water quantity is important for the mixture to complete the chemical reaction and provide proper workability. In this study, the Department of Environment (DOE) concrete mix design method was applied in the concrete block manufacturing process. Ordinary Portland cement (OPC) was used in all mixes. Crushed FCB (5-20 mm) and sand (<5 mm) were used as course and fine aggregates, respectively.

Three concrete cubes with 100×100×100 mm dimensions and two beams with 100×100×500 mm dimensions of each were selected in this study. The physical characteristics such as strength and slump were evaluated The specimens was demoulded after 24 hours casting and cured in the required curing condition.

RESULTS AND DISCUSSION

Recycling of clay based materials for the production of concrete block has revealed good potential of FCB as a substitute aggregate for natural coarse aggregate. Slump sizes were maintained between 30 mm to 60 mm by keeping constant operating parameters during the concrete block manufacturing process. The water content was varied to differentiate the concrete containing crushed FCB with concrete made from natural aggregates.

Figure 1 depicts the effect of coarse FCB aggregates replacement to water-cement ratio. Water-cement ratios increased as the percentages replacement of coarse FCB aggregate increased. This may be attributed to higher water content needed for mixes containing coarse FCB aggregate compared to normal concrete. Crushed FCB aggregate has higher water absorption owing to the porous feature of the clay. From the physical properties for course aggregate test, the percentages of water absorption between natural aggregates and FCB aggregate showed a very distinctive figure; 0.76 and 19.2% for natural coarse aggregate and crushed FCB aggregates, respectively. Thus, showing that the coarse FCB aggregates absorbed more water during mixing than natural aggregates. This finding is in agreement with the studies using crushed clay brick in concrete and paving block by other researchers (Zakaria and Cabrera, 1996; Padmini *et al.,* 2001; Poon *et al.,* 2006; Debieb and Kenai, 2007; Cachim *et al.*, 2008). However, the result contradicts with the study by Debieb and Kenai (2007) in which water-cement ratios decreased as coarse aggregates replacement increased. This could be due to the different methods used whereby coarse FCB aggregate were soaked with water for 24 hours prior to mixing. As a result, the coarse aggregates did not absorb any more water during mixing as the pores were already saturated with water. On the contrary, a large amount of water was absorbed during mixing in the present study as dry coarse FCB aggregates were used.

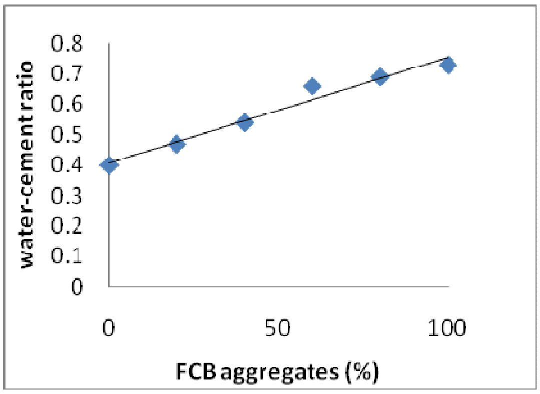

Figure 1: Effect of coarse FCB aggregates replacement to water-cement ratio of concrete block

The compressive strengths of various mixes are presented in Figure 2 for 7, 14 and 28 days of curing age. The compressive strengths for concrete of natural aggregates were higher than concrete containing coarse FCB aggregates starting from 7 days. This is in agreement with result by Zakaria and Cabrera (1996) who reported that the relatively lower strength at early curing age for brick and artificial aggregate concrete was attributed to the higher water absorption values of these aggregates. However, higher strengths were observed for the FCB concrete as the curing ages increase. In this study, compressive strengths of FCB concrete increased from 20% to 40% of coarse aggregates replacement, decreased from 60% to 80% and again increasing at 100% coarse aggregates replacement, respectively. It showed that substituting 40% of FCB aggregates after 28 days of curing produce maximum compressive strength of 48 MPa. However, this value was still lower than the compressive strength of normal concrete. The findings as illustrated by Figure 2 showed that the results obtained were contradict with the results found by Debieb and Kenai (2007), Poon *et al.* (2006) and Cachim *et al.* (2008), who stated that the higher the rate of substitution the lower the compressive strength. This difference was also reported by Barra de Oliveira and Vazquez (1996), who studied the influence of retained moisture in recycled aggregates on the mechanical properties and durability of new concrete.

The effects of three different moisture conditions (dry, saturated and semi-saturated) from the recycled aggregate were also compared and it was found that the use of dry aggregate prior to mixing yields concrete with higher compressive strength compared to using saturated aggregates. This finding may be interpolated to explain the fluctuating compressive strength of the present study. It is likely that the FCB aggregates used to replace the natural coarse aggregate by 40% and 100% are in dry condition while for 20%, 60% and 80%, the FCB aggregates were exposed to moisture during storage, hence lowering their compressive strength.

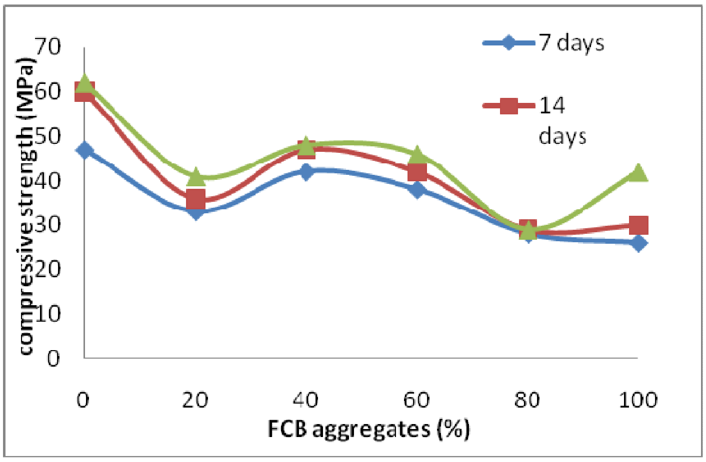

Figure 2: Concrete compressive strength with percentage replacement of coarse FCB aggregate

Generally, the angular shape of crushed material and its surface roughness were beneficial for a good bond between the crushed brick aggregates and the cement paste, thus increasing the flexural strength performances (Devenny and Khalaf, 1999; Debieb and Kenai, 2007). However, Figure 3 exhibits a more or less similar pattern to compressive strength, with maximum flexural strength observed at 40% coarse aggregates replacement.

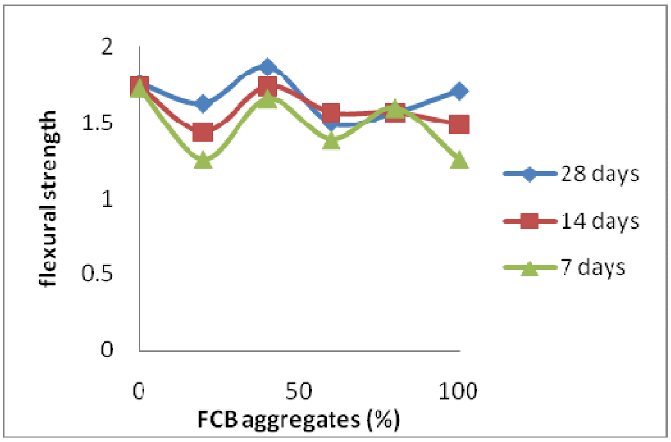

Figure 3: Concrete flexural strength with percentage replacement of coarse FCB aggregate

CONCLUSIONS

This study showed that the water-cement ratios slightly increased as the percentages replacement increased; the higher crushed brick substitution the higher was the water-cement ratio. This could be due to the porosity of the fired clay brick that required higher water content compared to natural aggregate in all mixes. Optimum compressive and flexural strength were obtained at 40% replacement of coarse aggregates after 28 days of curing period..

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