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Thermo-physical property test on clay bricks molded with different organic additives

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Abstract: Clay brick is one of the most important items used in the construction of houses in many of the African villages and cities. For this reason in this work an attempt is made at studying various clay bricks molded using clay and different organic additives (Neem leaves, Cow dung, Saw dust, and Rice husk) that are commonly found in the local communities. This study analyses the various thermal and physical properties of the bricks and it was found that the content of the organic additives do affect both the thermal and the physical properties of the clay brick.

Key words: Clay, brick, additives, thermal, waste, pores, agents and building.

1. Introduction

The environmentally friendly material recycling and energy saving are some of the most important research fields today. Also, as a result of environmental regulations, the demand for clay bricks with higher insulation ability is increasing. The thermal conductivity, density and specific heat capacity are very important for the heat-engineering concept of a thermally insulating material (Demir 2008).

One way to increase the insulation capacity of the brick is to generate porosity in the clay body. Combustible, organic types of pore-forming additives are most frequently used for this purpose. Rimpel and Scmedders (1996), determined the feasibility of the use of straw and reed residues, in clay brick production. Besides the composition of the waste, the feasibility also depends on the clay body's porosity and structure. To first order, the clay body density determines the thermal conductivity (Rimpel and Scmedders, 1996).

The commonly used pore formers in clay brick moulding are classified into two groups: organic and inorganic (Demir 2008).. Sawdust, rice husk, neem leaves and cow dung are some of the examples of organic pore-forming materials. Perlite, diatomite, calcite, pumice, and vermiculite are examples of inorganic (mineral) types of pore-forming agents. Organic pore formers are generally cheaper than inorganic ones (Demir 2008). Inorganic pore formers have less environmental problems (Schmidt-Reinholz, 1990; Krebs and Mortel, 1999; Junge, 2000, 2001). Organic product residues are extensively used as a pore former in the brick industry (Dondi et al., 1997).

Increased agricultural production and the development of agro-based industries in many countries in the world have brought about the production of large quantities of agricultural wastes, most of which are not adequately managed and utilized. Agricultural wastes have been used for animal feed, fertilizer, and fuel for energy production, but little work has been carried out to develop utilization of these wastes in the

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production of building materials (Demir 2008).

Ducman and Kopar (2001) carried out laboratory tests on specimens made of brick clay with up to 30% volume of sawdust and/or papermaking sludge as pore-forming agents. Both of these agents reinforce the structure of the ceramic body during drying and counteract cracking model's applicability.

2 Materials and method

Clay samples were collected from Wurno town. Wurno is the nearest place to the source of clay in Nigeria. Therefore clay samples were from Wurno town in Sokoto State, Nigeria. The samples were collected at a depth of 0.5 m and analyzed. The specimens were dried, crushed, and then sieved. The clay samples were crushed (using mortar and pestle) to their powdery forms. Fine aggregates were graded using sieve sizes between 1.18 and 60 mm. The cumulative mass of dry crushed samples used for the sieve analysis was approximately 200 g. About 20 g of each specimen was weighed and put into a conical flask which contained 20 mm of hydrogen peroxide as a catalyst. The mixture was properly stirred and then placed into a 1000 mm measuring cylinder containing de-ionized water. The solution was again stirred for 15 minutes and left to stand for another 15 minutes after which the percentage mass of solute was determined after every 10 minutes for a duration of 24 hours.

Additives (cow dung, saw dust, rice husk and neem leaves) were all collected at the Sokoto city site. These additives were chosen based on their availability, ease of collection and to recycle these natural wastes in the construction industry.

The method of mixing used in this work is hand mixing. For hand mixing of additives, the materials to be used are measured out by volume in a gauge. The proportion mix ratio of 3:7 of additives and pure clay were thoroughly mixed in clean surface using a shovel until a homogenous or suitable consistency was reached.

The additives were measured by volumes as 30% by volumes of each additive was added to 70% of clay in the preparation of samples 2 to 5, while sample 1 was 100% clay and sample 6 the last sample was a combination of 20% Neem Leaves and 10% Rice Husk. 30% additives was used on every sample this was done based on the studies by Ducman & Kopar (2001) in which it was found that the best performance (pore forming and strength) of additives is archived with 30% combination.

The samples were divided into six different series which are listed below.

Sample 1: Clay 100% Control
Sample 2: Clay 70% Cow Dung 30%
Sample 3: Clay 70% Saw Dust 30%
Sample 4: Clay 70% Rice Husk 30%
Sample 5: Clay 70% Neem Leave 30%
Sample 6: Clay 70% (Improved) Neem Leave 20% and Rice Husk 10%.

3. Results and discussion

3.1 Physical properties of clay, clay mixtures and bricks

The physical properties measured in this work include Bulk density, Particle density and Percentage porosity, the properties were compared for the different brick additive and the results were put in figure 1.

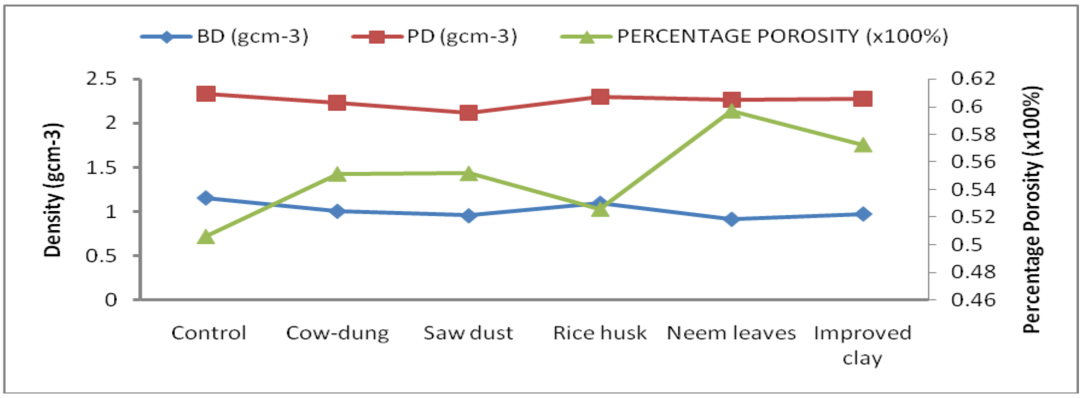

Figure 1 Bulk density, Particle density and Percentage porosity against Samples

Figure 1 shows, the graph of Bulk density, Particle density and Percentage porosity against Samples. This graph shows that if a higher particle density is required then much clay should be use in moulding the brick and saw dust is for low particle density. If higher bulk density is required, still much clay should be use and neem leave is for low bulk density. Again much neem leaves is needed for higher percentage porosity as against much clay which is for low percentage porosity. The improved clay sample has the lowest bulk density this will led to low density brick thus easy handling. It also has higher porosity which is for low thermal conductivity.

Singer and Munus (1996) have shown that the more the clay present in a material, the smaller the pore space (average porosity) and the greater the resistance to penetration at a given bulk density. Thus, if the samples consist of only clay at a specific bulk density, it will be difficult for the water to penetrate through the clay and shrinkage will occur which can cause cracking in the bricks.

With the help of the added mixtures, it will be helpful to reduce the bulk density thereby giving some pore space to the clay so that water will be able to enter through it and since clay material has high water retention capacity, the amount of water penetrated through will be hold and therefore, making the clay fit for brick production.

It can be observed that the control sample has the highest value of 2.33 (gcm^{-3}) followed by rice husk, improved clay, neem leaves, cow dung and with 2.30, 2.27, 2.26 and 2.23 respectably but saw dust sample has the lowest value of 2.12 (gcm^{-3}).

Plaster (1992) viewed that particle density depends on the nature of organic matter present in a material. This organic matter can cause the increment and reduction in it. The mixtures added in preparation of improved brick have caused the reduction in particle density of clay and also prevent cracking of the brick during aging. Therefore, making the clay with the improvement additives fit for clay brick production.

It can be observed that the neem leaves sample has the highest value of 0.5973(gcm-[3]) followed by improved clay, saw dust, cow dung and rice husk with 0.5727, 0.5519, 0.5516 and 0.5261 respectably but the control sample has the lowest value of 0.5063(gcm-[3]).

The increase in porosity due to the presence of additives may be as a result of trapped air bubbles that are interconnected. It can be concluded that samples with additives are more porous and absorbs more liquid. Since, the more, the pore space the greater the water that enters through the material. The mixtures added have help to moderate the amount of pore space in the sample. Therefore, the moderation makes the clay suitable for brick production.

3.2 Mechanical properties of various clay bricks

The Mechanical properties of the various bricks were measured, the properties are compressive strength, modulus of rigidity, water absorption and initial rate of absorption (IRA). The properties are then put in figure 2.

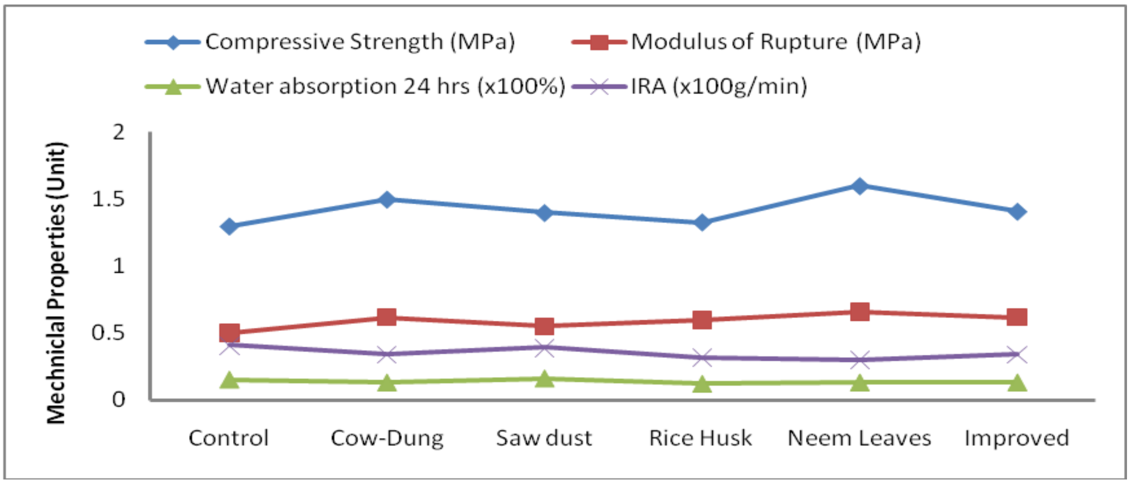

Figure 2: Graph of Mechanical properties of clay brick against Samples

Figure 2 shows, graph of Mechanical properties of clay brick against Samples. From the figure it can be observed that, if higher compressive strength or higher modulus of rupture are aimed at then much neem leaves is needed, for initial rate of absorption (IRA) much clay (Control) and for higher water absorption much saw dust should be added. The improved brick show average mechanical properties.

It can be observed that the neem leaves brick has the highest compressive strength, modulus of rupture and lowest IRA while control has the highest IRA and lowest compressive strength, modulus of rupture. Saw dust has the highest water absorption while neem leaves and rice husk are respectively with the lowest IRA and lowest water absorption. clay suitable for brick production.

3.3 Thermal properties of various clay bricks

The Thermal properties of the various bricks were measured. The properties are density, specific heat capacity and thermal conductivity. The properties are then put in figure 3. Figure 3 shows, a graph of thermal properties of clay brick against Samples. From the figure it can be observed that, if higher density or higher specific heat capacity are aimed at then much clay is needed in moulding the brick, for higher thermal conductivity much neem leaves is needed in the mixture.

It can be observed that the control brick has the highest density, highest specific heat capacity and low thermal conductivity while neem leaves has the lowest density, lowest specific heat capacity and highest thermal conductivity.

The reduction in the densities of the samples (other than the control) may be attributed to the replacement of clay by the additives in the mixture which has relatively lower density compared to that of the pure clay (control) sample. This may also be attributed to the coating of the clay by the additives which results to large particles with larger voids and hence less density (Osula, 1991).

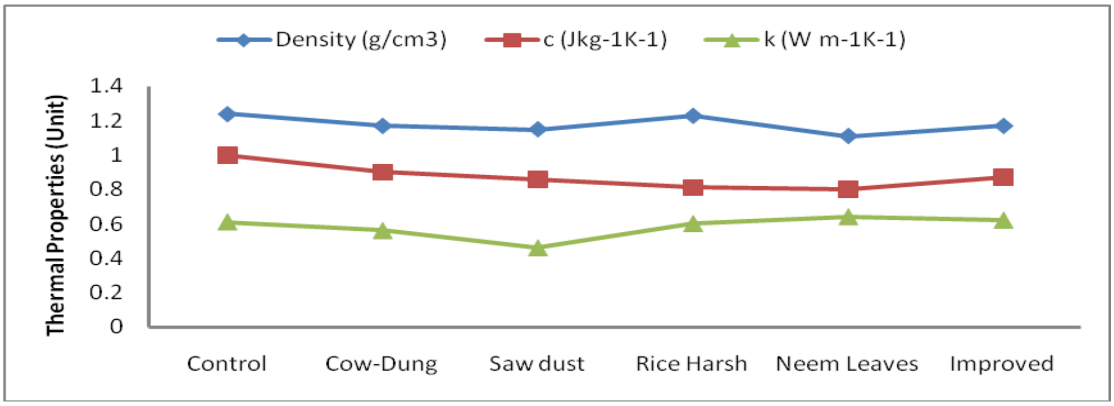

Figure 3: Graph of Thermal properties against Samples

The effects of using low density additives have been investigated by Maniatidis *et al.* (2007) in which it was found that while the addition of lightweight additives is successful in reducing density and therefore increasing thermal insulation, this compromises the aesthetic qualities. Again an excessive amount of organic additive can promote cracks due to low particle bonding and, consequently, reduce the mechanical strength (Tonnayopas *et al.*, 2008).

The density of the rice husk brick sample is 1.23 which is less than 1.54 obtained by Okpala (1993), 2.15 obtained by Sampaio *et al.* (2003) and 2.36 reported by Cook *et al.* (1977). The values of the thermal properties are source location, harvest-time and processing dependent.

4. Conclusion

Based on the experimental investigation reported in this paper, the following conclusions are drawn:

(a) The waste additive increased the open porosity and this effect decreased the bulk density and improved the thermal insulating properties.

(b) Compressive strength and modulus of ruptures values increase when an additive is added to the clay.

(c) The improved clay brick has the optimum thermo-physical properties

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