Durability of Sun Dried Clay Bricks Admixed with Cow Cone ash for Sustainable Development

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Abstract

Housing has remained a major challenge in Nigeria because of the increasing population and cost of building materials. To tackle the problem of housing deficit in the country, the government of Nigeria for some time now has been clamoring for the use of local materials in the construction industry to limit costs of construction. Thus, this paper looks at the potential of using cow-bone ash (CBA) to improve the durability of sun dried clay brick for sustainable development. Consistency properties, shrinkage, compressive strength and crack behavior of clay-cow-bone ash bricks were investigated in accordance with relevant codes and standards. It was however observed that, consistency properties and shrinkage decreased with increased percentage cow-bone ash addition while compressive strength and crack improved up to 10% CBA addition indicating that buildings made of clay-CBA composite could be more stable and durable than the ones made from clay alone. It is therefore recommended that Cow-bone ash can be used to improve the durability of clay brick at optimum addition level of 10%. Clay brick admixed with cow bone ash strongly contributes to the attainment of 12 out of the 17 sustainable development goals.

Keywords:
Clay brick; cow bone ash; durability; SDG, clay-CBA, compressive strength

1. Introduction

The United Nations (UN) has developed 17 primary global objectives to be achieved by 2030. These objectives mainly focused on eradicating poverty,

sustainable development and fighting climate change. Current trends in Civil engineering are aimed at adopting SDGs by achieving sustainable infrastructure. Housing is one of the basic and most important human needs, through which its adequate provision can lead to attainment of all or most of the SDGs, however, it remains a major challenge in developing countries like Nigeria because of the increasing cost of building materials; chiefly cement, as identified by Oluwatuyi and Olayemi (2012) and Andrew (2007). To tackle the problem of housing deficit in the country, the government of Nigeria, for some time now, has been clamoring for the use of local materials in the construction industry to limit costs of construction. Consequently, researchers have since taken up the challenge of sourcing and developing alternative local construction materials. Clay has proven to be a sustainable and economical construction material that has been used by man since his existence. Its use is obsolete for modern day constructions, however, about one-fifth of the world population still use it for provision of shelter (Ogah and Amos, 2011) because of the ease to excavate from the ground with little or no process required; hence energy consumption, emission of toxic gases due to processing and many other time consuming processes are spared. As a structural unit, clay is used to form bricks either sun-dried or fired which is well-known and widespread due to its durability and local production by local composition and labour. On the other hand, cow-bone ash, which is an agro waste, has been reported by many researchers to improve the properties of concrete (Falade et al., 2012,2013; Abubakar et al., 2016; Akhionbare, 2013 and Adaba et al., 2012), thus, this paper looked into the durability of clay-bone-ash composite brick for sustainable housing in the country.

2. Materials and Method

Materials used include clay soil, cow bone ash (CBA) and water. CBA was obtained from incineration of cow bones in a furnace at a temperature of 900^{o}C (Abubakar, et al., 2016). The residue was ground in a hammer mill to fine powder and sieved through 75 micron BS sieve to obtain the required degree of fineness (Aribisala and Bamisaye, 2006). Physical properties of the clay were determined in accordance with relevant codes and standards: specific gravity (BS812, 1975); plasticity index (BS 1377, 1990) and shrinkage (EN 680, 1993); as well as the chemical composition analysis of the CBA using x-ray fluorescence analysis.

CBA was mixed using 0, 5, 10, 15 and 20 per cents by weight of the clay sample. A uniform mix for each batch was achieved by mixing the ash and clay thoroughly. Water was added until a workable mix was achieved. Brick moulds of size 100 x 130 x 260mm were cast (BS 3921, 1981). The bricks were sun dried for 28 days and afterwards subjected to compression test according to BS 1881, part 116 (1983) and observed for visible cracks.

3. Results And Discussion

3.1 Specific gravity

The specific gravity of the clay used is 2.70. However, Ogah and Amos (2011) gave specific gravity for cohesive soils as 2.68-2.72, which implies that the specific gravity of the clay used is within the specified range for cohesive soils while that of CBA is 2.27 which also means that CBA is not a cohesive material.

3.2 Chemical analysis

The result of chemical analysis on cow-bone ash is presented in Table 1. It is observed that bone ash has combined SiO_2, Al_2O_3, and Fe_2O_3 oxides content less than 50% as specified by ASTM C618 (2005); and thus, can be considered as non-pozzolanic material, which is in agreement with Akhionbare (2013). However, its high CaO content makes it a valuable material. The loss on ignition of the bone ash is 11.3%. This value is a little more than the limit of 10% set by ASTM C618 (2005).

Table 1: Oxide composition of CBA

Oxide	CaO	SiO_2	Al_2O_3	Fe_2O_3	SO_3	LoI
% in CBA	55.82	3.2	6.29	1.66	0	11.30
% in clay	0.80	60.27	15.13	7.71	0.56	-

3.3 Consistency property

The values of plastic and liquid limits, plasticity Index, and the shrinkage are shown in Figure 1. The results show decrease in the plasticity index of the clay with percentage increase in CBA addition up to 10% and increases afterwards. This indicates that CBA has good stabilizing property on clay. On the other hand, both liquid limit and plasticity index decrease with increase in percentage CBA addition while shrinkage also decreased with increase percentage CBA addition up to 10% and became almost constant afterwards,

indicating that buildings made of clay-CBA composite could be more stable than the ones made from clay alone.

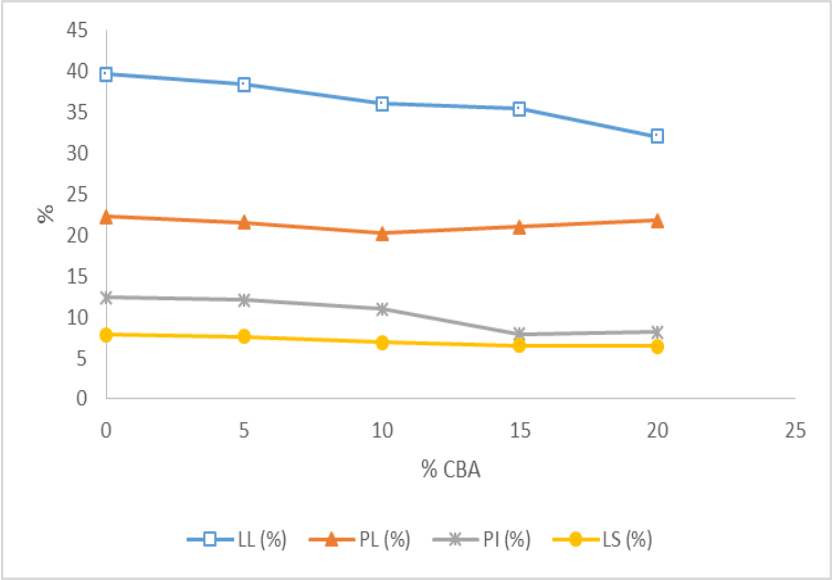

Figure 1: Consistency properties and shrinkage of clay-bone ash composite

3.4 Compressive strength

Figure 2 shows the result of 7 and 28 days compressive strength of clay-bone ash composite brick, it can be observed that at both 7 and 28days, the compressive strength increased with increase in percentage CBA addition up to 10% and decreased after that, this is because addition of CBA in clay reduces the amount of silicon dioxide which is responsible for clay strength. However, the outlier observed at 20% CBA addition for 28days compressive strength could be as a result of experimental errors.

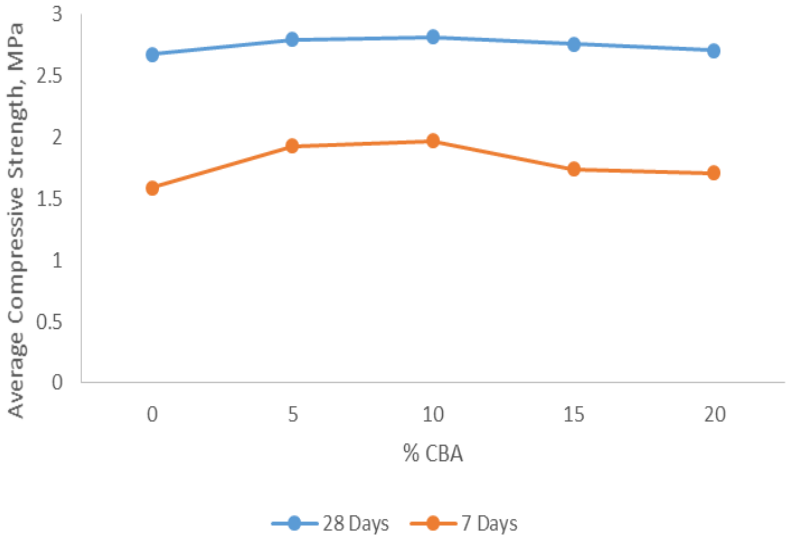

Figure 2: Compressive strength with %CBA addition

3.5 Cracks

The crack behavior of the clay bone ash composite brick was ascertained using direct visual observation at 28days. It was observed that the crack in the specimen varies with drying period and percentage cow bone ash addition. Visible cracks were observed at 0% and 5% CBA addition while at 10% and 15% stabilization it was observed that there were no visible cracks. However at 20% CBA addition, the cracks observed were more pronounced than in all other percentage additions. This can be attributed to the fact that at 20% inclusion, the CBA inhibits proper bonding between the particles of the clay thus causing the cracking.

Figure 3: Crack Propagation in the Brick

4. Conclusion

From the results obtained, it can be concluded that:

1. Cow bone ash can be used to improve the durability of clay brick at optimum addition level of 10%
2. The quest by the government of Nigeria for use of locally available materials for sustainable development can be met with the use of clay-cow-bone ash composite brick.
3. The economic potential of the people involved in the processing of cow bone will be enhanced thereby reducing unemployment and poverty level in the country.
4. The use of clay brick admixed with cow bone ash will lead to attainment of sustainable development goal numbers 3,6,7, 8,9,10, 11,12,13,14,15, and 17

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