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Effect of Coconut Shell Ash on Properties of Fired Clay Brick

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Abstract: **This study analyzed the influence of coconut shell ash CSA on the properties of burnt clay bricks. 2 to 10 % CSA was blended with the clay. Atterberg limits, specific gravity and compaction tests were conducted on the soil sample while density, water absorption and compressive strength tests were conducted on fired clay bricks at variable admixture content. The results show that the addition of CSA improves the strength properties of fired clay bricks. The optimum amount of CSA to be added for the production of fired clay bricks was found to be 2%.**

Keywords: **sawdust ash, temperature, lateritic soil bricks.**

1. INTRODUCTION

There is a wide range of material available for the construction industries. The choice and sustainability of a particular material depends largely on its availability, nature of project, individual preference, durability, proximity and economic consideration.

Cocos Nucifera trees, otherwise known as coconut palm trees, grow abundantly along the coast line of countries within 15^0 of the equator. They prosper in sandy, saline soil and in tropical climates. A healthy coconut tree will produce approximately 120 watermelon-sized husks and shells per year, each with a coconut imbedded inside. There are three constituents of the Cocos Nucifera that can be used for fuel: the husk, the coconut shell, and the coconut oil that is in the white coconut "meat" or copra as it is usually called. Thus, the coconut tree is a very abundant, renewable resource of energy. When coconuts are harvested, the husks are removed, thereby leaving the shell and the copra. These husks are considered as waste materials and are usually dumped into refuse bin. When consumers buy the coconut, they buy it with the shell and when it is to be consumed it is broken and the shell is removed. Large quantities of the shells can be obtained in places where coconut meat is used in food processing. The husk and the shell are both regarded as waste materials. The shells are then burnt into ashes in a furnace at a very high temperature to produce the coconut shell ash.

Utilization of these industrial wastes to improve on the engineering properties of clay bricks would serve as a means of disposing of these waste as their primary means of disposal currently is on land. More so, as Nigeria is currently undergoing a 'zero emission' i.e. no industrial waste should be left unused, this research will serve as a mean of recycling these industrial wastes.

Burnt or rather fired clay bricks are made by forming a plastic mixture of a suitable soil and water in to appropriately shaped units, drying the units and then firing or burning them in a kiln.

Clay soils and lateritic soil are the most commonly used soil for brick manufacture. Firing them at high temperature (400-1200^0c) results in a relatively higher compressive strength and other engineering properties and sometimes even performs better than some sandcrete blocks [1].Industrial and agricultural wastes can be used to improve on the engineering properties of most of the clay soils.

More recently, clay soil improvement/stabilization has found use for industrial and agricultural waste such as rice husk and other pozzolanic materials [2, 3], rice husk ash [4] and sawdust [5]. [5] Reported that at relatively small concentrations 2 % by weight of sawdust additive greatly enhanced the properties of burnt brick and that additives above 3 % by weight were found to be deleterious. [3] Recommended that important properties of burnt bricks such as compressive strength and water absorption can be improved substantially by adding rice husks.

[6] Reported that the liquid limit, plastic limit and CBR value of alluvial soil increases with addition of Kolaghat pond ash and rice husk ash. [7] Found that the optimum amount of rice husk ash for stabilization of cement added lateritic soil is 6%. [8], conducted different studies on lateritic soil using different stabilizing agents like sugarcane ash, bamboo leaf ash, coconut husk and shell ash etc and showed the improvement of engineering properties of the soil. [9], Discovered that 7% coconut shell, leaf and husk ash can be used to stabilize lateritic soil for pavement construction.

Bricks are classified based on the average or minimum compressive strength, linear shrinkage, density and the percentage water absorption. According to this classification, minimum compressive strength of bricks should be 3.5 MN/m^2 and the water absorption should not exceed 20 %. [10]. [11] sets 20.7 N/mm^2, 17.2 N/mm^2 and 10.3 N/mm^2 as the minimum fired compressive strengths for Grade SW (Severe weather), Grade MW (moderate weather) and Grade NW.

[1] specified minimum density requirement of 2.0Mg/m^3.

[12] specified 15% linear shrinkage limit for bricks of classes 3.5N/mm^2 to 12N/mm^2 .

The present study concentrates on the effect of coconut shell ash on the properties of fired clay bricks.

2. MATERIALS AND METHODS

2.1. Soil

A disturbed soil sample used for this study was obtained from Dawakin Tofa Local Government, Kano State. It was collected from a pit about 1m depth with the aid of hoe. Table presents the basic characterization of the soil resulted from Experiments conducted on the soil sample at Laboratory of Civil Engineering Department, Bayero University Kano.

Table 1. Basic characterization of soil

Soil properties	Values
Natural moisture	12.2%
Liquid limit(LL)	39.3%
Plastic limit(PL)	19.2%
Plasticity index(PI)	20.1%
Linear shrinkage LS	10%
Specific gravity(G.S)	2.75
MDD	1.62MN/m^3
OMC	18.2%
Particle size distribution	
Sand	36%
Clay	40.4%
Silt	21.6%
AASHTO classification	A-6

2.2. Coconut shell ash CSA

The coconut shells were obtained from a market waste dump. They were subsequently spread on matting and allowed to properly dry to facilitate proper combustion during burning. This material was burnt into ashes in a furnace at a temperature of 500 – 550^{0}c for 2 hours to produce the coconut shell ash. The ash was allowed to cool and kept in an air tide container.

Table 2. Oxides composition of CSA.

Oxides	Compositions
SiO_2	44.05
Al_2O_3	14.60
Fe_2O_3	12.40
CaO	4.57
MgO	14.20
MnO	0.22
Na_2O	0.45
K_2O	0.52
ZnO	0.3
LOI	8.69

Experimental Program and Results.

Note: All the tests were conducted as per [13, 14].

3. ATTERBERG'S LIMIT TESTS

The liquid limit and plastic limit tests were conducted on the soils with and without CSA.

3.1. Effect of CSA on Liquid Limit, Plastic Limit and Plasticity Index.

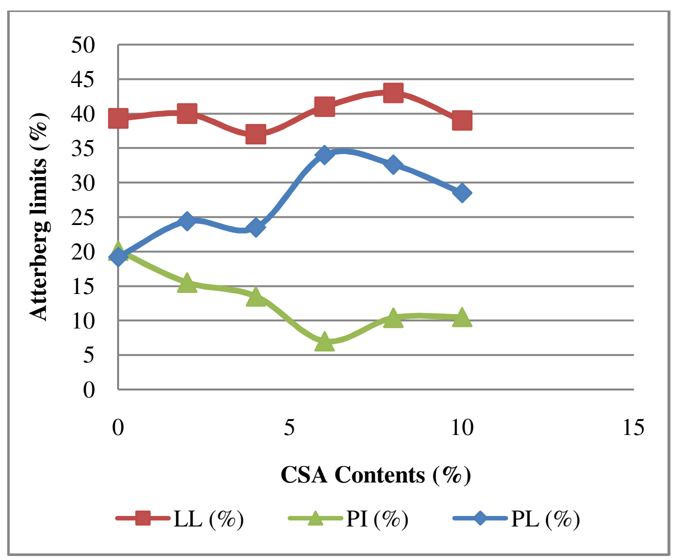

Fig.1. Effect of CSA on LL, PL and PI

LL, PL and PI tests were conducted on sample after adding 0, 2, 4, 6, 8 and 10% CSA in it. From the experimental results it is observed that the liquid limit is minimum when CSA added is 4%, the plastic limit increases with increase in %CSA content but the variation is marginal, which is clear from fig.1, while Plasticity index decreases with increase in CSA content. The reduction in the PI may be because of the decrease in the amount of clay sized fraction owing to the flocculation and agglomeration of clay particles and also the formation of cementitious compounds of greater effective grain size as a result of pozzolanic action of CSA. The plasticity index is minimum when 6%CSA is added which is clear from fig. 1

4. COMPACTION TEST

Standard compaction tests were conducted on the sample after addition of 0, 2, 4, 6, 8 and 10% CSA in it to find out the effect of CSA on maximum dry density MDD and optimum moisture content OMC of the soil sample.

4.1. Effect of CSA on MDD and OMC

Optimum moisture content of the soil is found to increase with increase in CSA content in general; this may be attributed to the fact that CSA absorbs more moisture when added to the clay which may be required for the pozolanic reaction. Also from the compaction test results it is observed that the Maximum dry density of the soil increases at 2% CSA and then continue to decrease with the increase in CSA content. This may be attributed to the molecular rearrangement resulting in the formation of transitional compounds of different densities. Maximum dry density is maximum at 2% CSA. Fig. 2 shows the effect of CSA on maximum dry density and optimum moisture content.

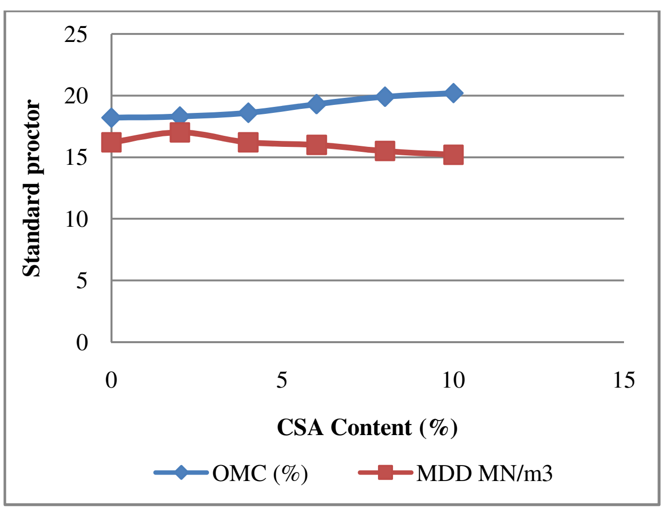

Fig. 2. Effect of CSA on MDD and OMC

5. BRICKS PRODUCTION

The Different percentages of CSA (0, 2, 4, 6, 8 and 10 of dry weight of soil) were thoroughly mixed dry according to their proportion by weight. The required amount of water approximately the optimum moisture content for each determined previously was added gradually and mixed thoroughly with shovel until a uniform homogenous mix was obtained. The mould inner surface was oiled or lubricated and the soil put into $100mm \times 100mm \times 100mm$ mould in three layers, each layer compacted by receiving 27 blows from a rod, the surface leveled and smoothened with straight edge and trowel.

The molded brick was extruded by loosening the mold and carefully removing the brick. The brick was cured at room temperature for 12 days prior to burning.

Three bricks were molded for each test and level respectively. After careful drying and curing at room temperature, the bricks were subsequently fired in an electric furnace with a rise of 200^{o}C/h and a 4 hour soak at 800^{o}C.

6. AVERAGE DENSITY OF BRICKS (MG/M^3)

Density tests were conducted on the bricks produced after adding 0, 2, 4, 6, 8and 10% CSA in the soil samples respectively. Density of the bricks was measured by weighing the bricks dry and dividing by the volume of each brick. The volume of each brick was calculated approximately by taking the reduced lengths of the sides after firing. Three $100mm$ ×100mm×100mm sized bricks were tested at each % of CSA and average is taking as the density of the brick at that level.

6.1. Effect of CSA on the Density of Fired Clay Bricks.

From the results of the experiment conducted, the density decreases with the increase in %CSA content. Only bricks at 2%CSA satisfy the requirements as per BS3921: British standard specifications for bricks which stated the minimum density of 2Mg/m^3. As shown in fig.3

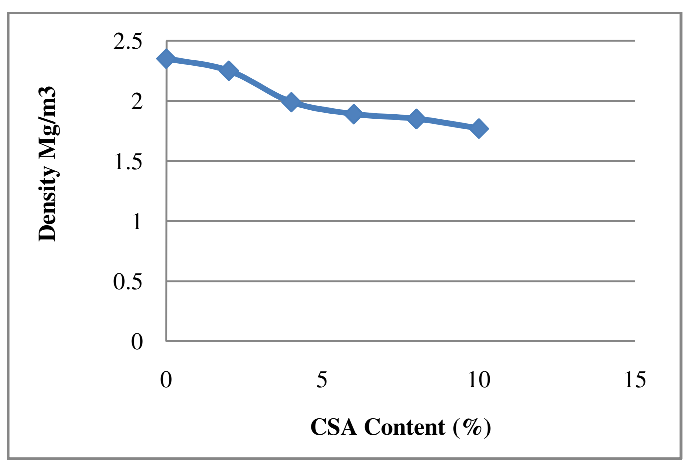

Fig. 3. Effect of CSA content on the density of the bricks

7. AVERAGE WATER ABSORPTION OF BRICKS (%).

Water absorption tests were conducted on bricks produced after adding 0, 2, 4, 6, 8 and 10% CSA in the samples. The water absorption of a brick is a measure of its porosity. Some degree of porosity is desirable but highly porous bricks may absorb and transmit too much water and thus may swell and shrink or may lack durability. Water absorption was measured by immersion of the bricks in cold water for 24 hours and expressing the water absorbed as a percentage of its dry weight. The water absorbed is given by the relation;

Water absorption = (B – A)/A $\times$ 100……I
Where B = saturated weight of bricks, A = dry weight of bricks.
3 specimens were tested for each level. The average of these values gives the water absorption.

7.1 Effect of CSA on Water Absorption of Fired Clay Bricks

From the experiment conducted, water absorption decreases at 2%CSA after which it continue to increase with increase in %CSA. All the results conform to the BS specification of water absorption not to exceed 20% except for the 10% CSA adding which is 20.2%. Water absorption of as low as 14.7% is obtained at 2%CSA addition; this can be confirmed from fig.4 below

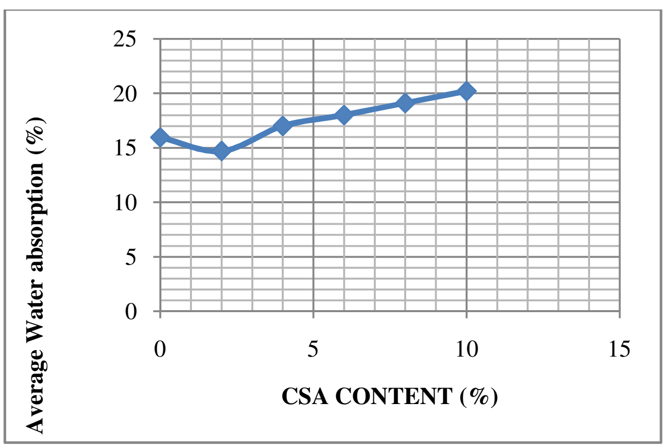

Fig. 4. Effect of %CSA content on water absorption of the fired bricks.

8. AVERAGE COMPRESSIVE STRENGTH OF BRICKS.

The compressive strength tests of the bricks were carried out after testing for water absorption and allowing drying at 50^0c for 24 hours. Avery dennison universal testing machine at civil engineering laboratory faculty of engineering Bayero University Kano was used. The specimens were packed at the bottom. The compressive strength of bricks was read with the aid of a load meter readable to 0.1KN attached to the machine. Three brick cubes were tested at each level. The average value recorded as the compressive strength of the bricks in MN/m^2.

8.1. Effect of CSA on Compressive Strength of Fired Clay Bricks.

The result showed increase in the compressive strength at 2%CSA after which the compressive strength continue to decrease with increase in %CSA content. The compressive strength is maximum at 2% CSA with a value of 18.5MN/m^2.fig.5 showed the effect of CSA content on the compressive strength of the bricks at various % 0f CSA.

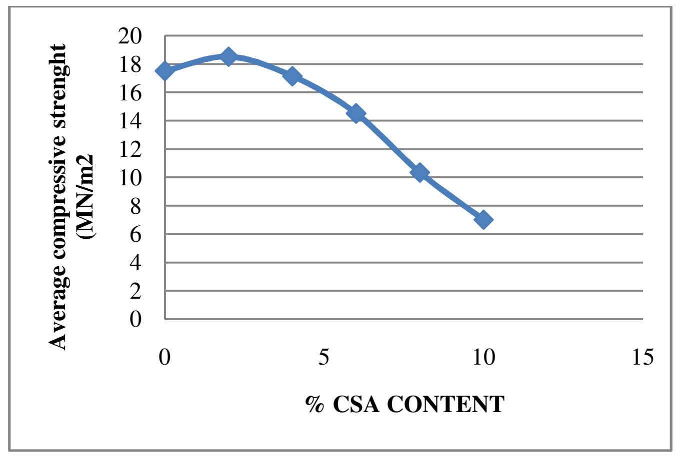

Fig.5. Effect of CSA on compressive strength of the fired bricks.

9. CONCLUSION

From the various tests performed by adding different amount of CSA, it can be concluded that addition of CSA improve the properties of fired clay bricks within the limit of experimental error.

All the results pointed that addition of 2%CSA gives optimum performance with the increase in compressive strength by 7.89%, reduction in water absorption by 5.71% and reduction in density by 4.25% compared to 0% CSA respectively.

2% CSA can be recommended for use in improving the properties of fired clay bricks.

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