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Potentials of Using Sawdust Ash and Iron Ore Tailings in the Production of Burnt Clay Bricks

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Abstract— *This study scrutinizes the influence of sawdust ash (SDA) and iron ore tailings (IOT) on the properties of burnt clay bricks. Initially the virgin soil was blended with 5 to 30%SDA. 5%SDA found to be the optimum of SDA, this percentage is then mixed with 10, 20 and 30% of IOT in order to obtain the best combination. Atterberg limits, specific gravity and standard proctor tests conducted on the virgin soil sample while density, water absorption, linear shrinkage and compressive strength tests were conducted on fired clay bricks at variable admixture content. The results show that Soil + 5%SDA + 30%IOT give the best performance and can be recommended for use so that these wastes can be turned in to something useful.*

Keywords: *Sawdust ash (SDA), Iron Ore Tailings (IOT), Temperature and Burnt Clay Bricks.*

1. INTRODUCTION

In the quest for economy, quality, and sustainable development in Civil Engineering sector, it is imperative to find a suitable alternative to reduce the dependence on cement as the primary building material because of its high cost and associated hazard related to its manufacture. Shelter has being a biggest challenge especially to Rural dwellers and low-income earners in developing and third world countries because of the high cost of building materials and monopoly or rather over dependent on a particular material as in the case of cement. These makes shelter almost impossible to acquire there by leaving people stranded, with no choice than to sleep on the streets beside gutters etc. this lead to the evolution of several diseases in such countries, In Nigeria, industrial wastes such as sawdust and iron ore tailings are produce everyday in massive quantity there by creating nuisance in the environment. One can easily apply this simple technology to erect or build himself a house with better quality and durability.

Sawdust is a by-product obtained after processing wood in the company, market or carpenters shop. Burning it at high temperature results in the production of sawdust ash. Many researchers elucidate the potentials of using SDA as an admixture in many applications. [1, 2, 3, 4, 5, 6, & 7].

During the production of iron from its ore, a lot of wastes are produced among which is iron ore tailings. Iron ore is a ferruginous quartzite deposit of geological reserve. Tailings are the materials left over after the process of separating the valuable fraction from the worthless fraction of an ore. The composition of tailings is directly dependent on the composition of the ore and the process of mineral extraction used on the ore. The uses of IOT for various applications in civil engineering have also been explicated by many researchers; [8, 9 & 10]. [11] found out that when 40% of fine aggregate is replaced with IOT in gives appreciable strength. [12] Found out that addition of wood ash in bricks making increase the compressive strength more than rise husk ash and fly ash.

Burnt 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. A wide variety of soil is suitable for the manufacture of burnt clay bricks. The essential property is plasticity: the ability to be molded or shaped by pressure working which is imparted by clay particles. The proportion of clay needed to impart sufficient plasticity is not very large because soil with large clay content often exhibits too much shrinkage which causes cracking and distortion.

[13] Realized that wood ash offers more advantages than sawdust ash when used as an admixture in burnt laterite-clay bricks.

Utilization of these industrial wastes to improve on the engineering properties of clay bricks would serve as yet another means of disposing of these wastes as their primary means of disposal mostly 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.

Bricks are classified based on compressive strength, linear shrinkage, density and 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% [14]. [15] specified minimum density requirement of 2.0Mg/m^3. [14] 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 SDA and IOT on the properties of burnt clay bricks based on compressive strength, linear shrinkage, density and the percentage water absorption. Initially SDA optimum is obtained, and then mixed with various percentages of IOT.

2. MATERIALS AND METHOD

2.1. Soil

Soil sample used for this study was obtained from Dawakin Tofa Local Government Area, Kano State. It was collected from a pit of about 1m depth with the aid of hoe. Predominant occupation of people leaving in the area is pottery, as the soil offers greater advantage in making pots; they also use it to erect houses for themselves. Preliminary tests conducted for basic characterization of the soil is presented below. All tests conducted in accordance with [16].

Table 1: Soil properties

Properties	Values	Unit
Natural moisture	12.2	%
Liquid limit(LL)	43%	%
Plastic limit(PL)	18.8	%
Plasticity index(PI)	24.2	%
Linear shrinkage LS	10	%
Specific gravity(G.S)	2.75	
MDD	1.62	MN/m3
OMC	18.2	%
Gravel	1	%
Sand	37	%
Clay	37.5	%
Silt	24.5	%
IS Classification	CI	

2.2. Saw Dust Ash (SDA)

The Sawdust used for the production of the bricks was obtained from the timber shed at Yan katako, Rijiyar lemo Kano. The dominant species of the timber according to oral investigation were Afara, Iroko, and Mahogany. The sawdust was burnt at a high temperature and allowed to cool for 24 hours thereafter sieved through 425µm BS sieve and stored in a water tight container to avoid absorption of moisture.

2.3. Iron Ore Tailings (IOT)

The iron ore tailing was obtained from Nigerian iron ore mining company (NIOMCO) at Itakpe in Kogi State. The sample was crushed in a crushing machine and subsequently sieved through 212µm BS sieve.

3. EXPERIMENTAL PROGRAM AND RESULTS

Note: All the tests were conducted as per [16 & 17]

3.1. Standard Proctor Test

In order to obtain the maximum dry density (MDD) and optimum moisture content (OMC) of each mix, standard proctor test was conducted on soil mix with 0, 5, 10, 20, and 30%SDA after which the optimum %SDA found through series of tests was then mixed with the soil and 10, 20 and 30%IOT and the test repeated at each replacement level.

3.2. Effect of SDA on MDD and OMC of the Soil

Compared to the MMD of the virgin soil, there is a trend of decrease in MDD as the soil is replaced with 5, 10, 20 and 30% of SDA. This of course is anticipated because the specific gravity of SDA is less than that of the soil. MDD of the virgin soil is equal to that of the soil + 5%SDA. OMC of the soil is found to increase with increase in SDA content in general; this may be attributed to the fact that SDA absorbs more moisture when added to the clay which may be required for the pozolanic reaction. Table 2 shows the variations.

Table 2 MDDs and OMCs of Soil Mixed with SDA

SDA (%)	MDD (MN/m3)	OMC (%)
0	16.4	18.1
5	16.4	19.83
10	16.1	20.9
20	15.8	24
30	15.4	24.8

3.3. Effect of SDA and IOT on the MDDs and OMCs of the Soil

When IOT is added to the Soil + SDA, MDD decreases initially and then continue to increase as the IOT is increased. This can be ascribed to the fact that specific gravity of the IOT is greater than that of the SDA. MDD at 30%IOT is almost equal to that of the virgin soil. OMC tend to reduce with the addition of IOT contents, with the OMC at 30%IOT close to that of the virgin soil. This is clearly explained in table 3.

Table 3: MDDs and OMCs of Soil Mixed with SDA and IOT

IOT (%)	MDD (MN/m3)	OMC (%)
0	16.4	18.1
10	14.3	23.8
20	15.9	20.8
30	16.3	19.6

4. BRICKS PRODUCTION

At first, mass of dry soil required to fill the mould was obtained from MDDs, at different percentages of SDA (0, 5, 10, 20 and 30 of dry weight of soil). Soil and SDA 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 7 days after which it is oven dried at 50^0C for 24hours to dissipate the remaining moisture prior to burning. Three bricks are molded for each test and percentage respectively. After careful drying and curing, the bricks were subsequently fired in an electric furnace with a rise of 250^oC/h and a 4 hour soak at 1000^oC.

5. BRICKS TREATED WITH SDA

Bricks are produced when Soil is replaced with 0, 5, 10, 20 and 30% of SDA. Three bricks are produced for each test at each percentage of SDA.

5.1. Effect of SDA on Density of Bricks

Density of the bricks is measured by weighing the bricks dry and dividing by the volume of each brick. The volume of each brick calculated approximately by taking the reduced lengths of the sides after firing. From Fig 3 it can be clearly seen that density of bricks decreases with increasing SDA. All the bricks that were fired with SDA fail to satisfy the minimum standard density requirement of 2Mg/m^3 for common load bricks as per BS 3921 (specification for clay soil bricks).

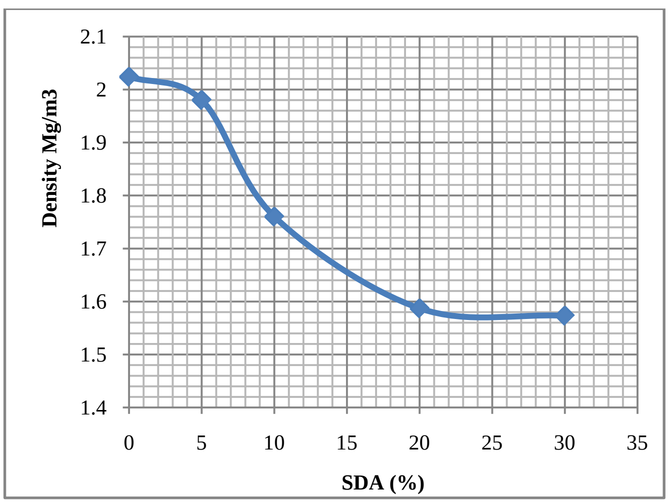

Fig. 1: Density of Bricks Treated With SDA.

5.2. Effect of SDA on Linear Shrinkage of Bricks

The linear shrinkage was conducted at two stages; one after drying the bricks at 50^0c for 24 hours and the parameter measured was the drying shrinkage and; two, after firing at the required temperature and the parameter measured was firing shrinkage.

The linear shrinkage, which is a combination of the drying and firing shrinkage, was expressed as a percentage of the original length of the bricks. The shrinkage was measured with the aid of a digital vernier caliper readable to 0.01mm. The average of the two sides of each brick was taken as its linear shrinkage. Fig 4 shows clear reduction in the linear shrinkage as SDA is added.

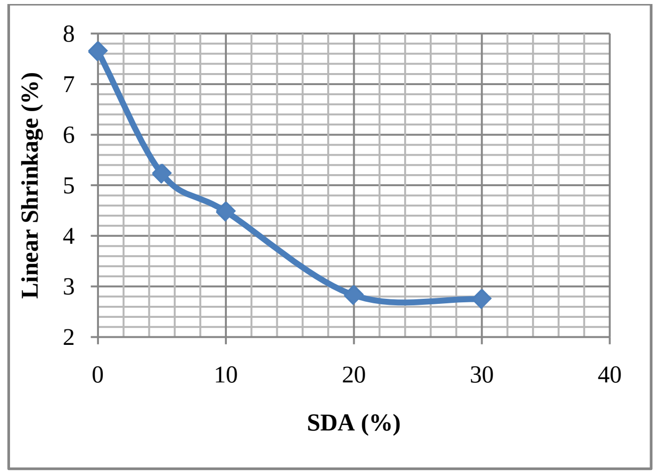

Fig. 2: Linear Shrinkage of Bricks Treated With SDA.

5.3. Effect of SDA on Water Absorption of Bricks

The water absorption of a brick is a measure of its porosity. 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. Only bricks at 5 and 10%SDA conform to the BS specification of water absorption not to exceed 20%.

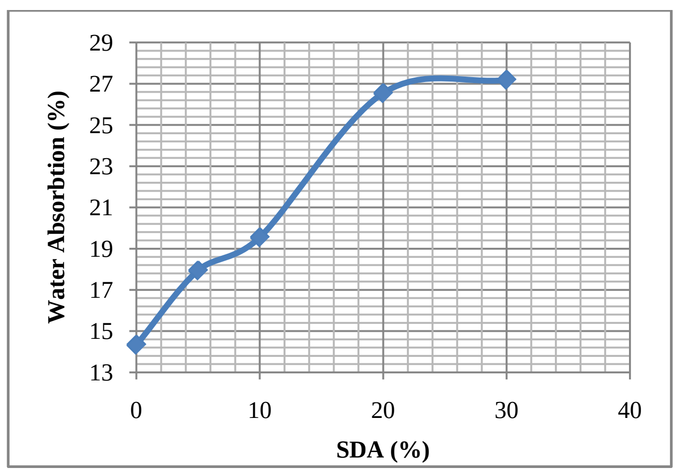

Fig. 3: Water Absorption of Bricks Treated With SDA

5.4. Effect of SDA on 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. Fig 4 depicts a clear reduction in compressive strength as SDA is added. Only bricks at 5%SDA came close to that of 0%.

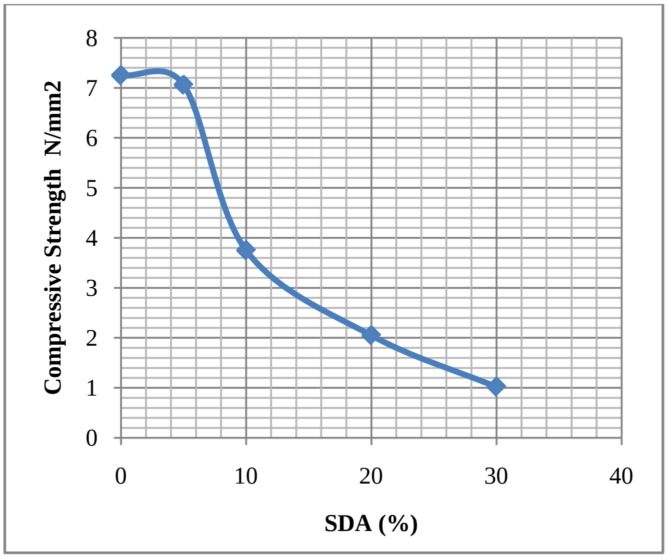

Fig. 4: Compressive Strength of Bricks Treated With SDA.

Based on these results it can be ascertained that 5%SDA is the optimum. This optimum is then mixed with soil and various percentages of IOT and the same tests were repeated.

6. BRICKS TREATED WITH SDA AND IOT

Soil is replaced with 5%SDA and IOT in 10, 20 and 30% respectively. Bricked produced at these levels are also analyzed based on density, linear shrinkage water absorption and compressive strength respectively.

6.1. Effect of SDA and IOT on Density of Bricks

Bricks at 20%IOT and 30%IOT conform to the BS specification of 2Mg/m^3 with better density at 30%IOT as shown in Fig 5.

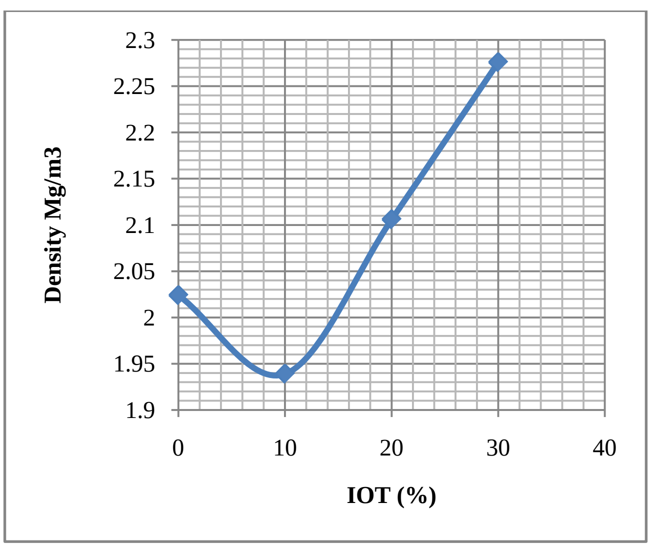

Fig. 5: Effect of SDA and IOT on Density of Burnt Clay Bricks.

6.2. Linear Shrinkage

Obvious reduction in linear shrinkage is depicted in Fig 6 below. All the bricks fall within the max of 15% as recommended.

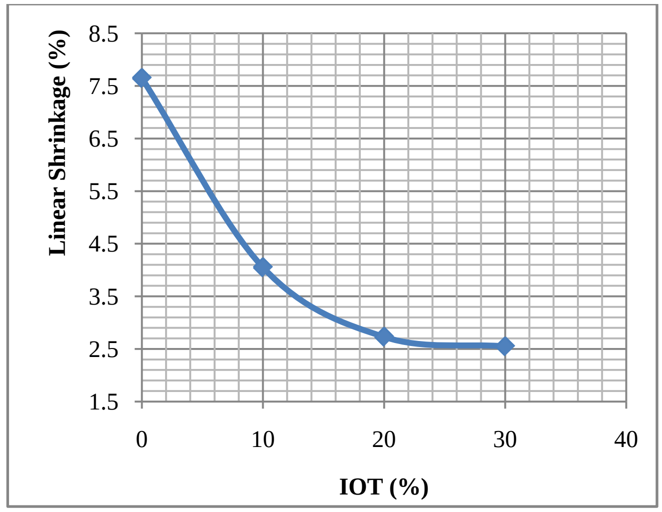

Fig. 6: Effect of SDA and IOT on Linear Shrinkage of Bricks.

6.3. Water Absorption

Compared to control, water absorption raise at 10%IOT and then continue to drop as the IOT is increased. Water absorption of as low as 12.8% is noticed from Fig 7.

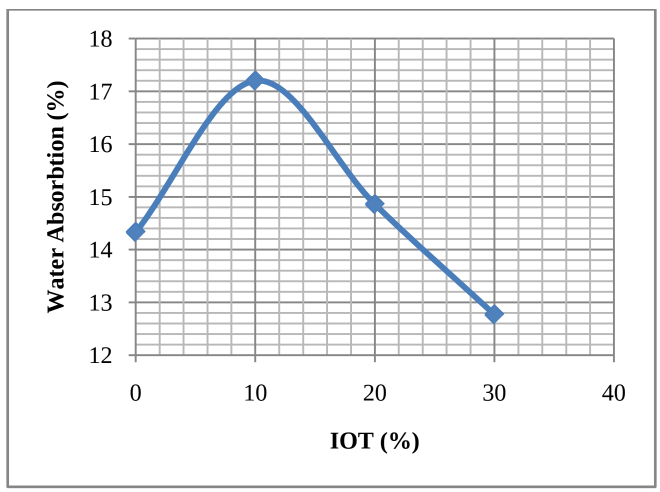

Fig. 7: Water Absorption of Bricks Treated SDA and IOT.

6.4. Effect of SDA and IOT on Compressive Strength of Bricks

Noticeable increase in compressive strength is observed from fig 10 as IOT percentage is increase. Compressive strength at all IOT percentages is greater than that of the control. All bricks produced fall within the range 3.5 – 12N/mm^2 recommended by standard.

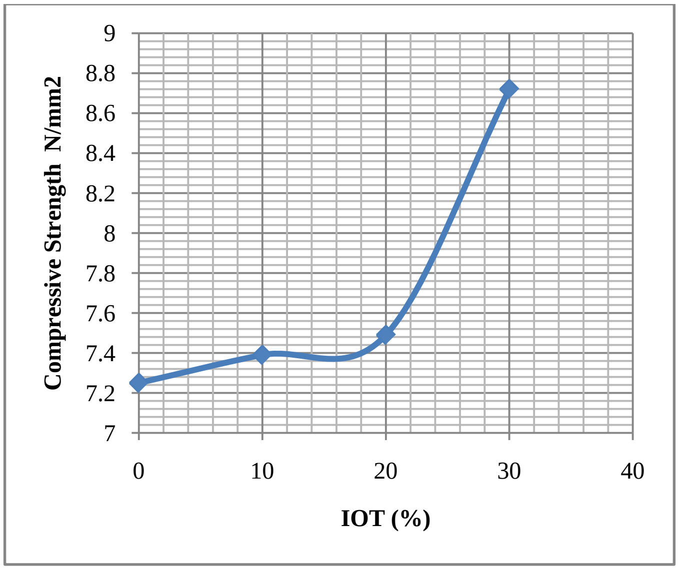

Fig. 8: Compressive Strength of Bricks Treated with SDA and IOT.

7. CONCLUSION

Based on the results analysis and comparism with standards, it can be seen that Soil + 5%SDA + 30%IOT is the optimum having satisfied all the requirements more than the rest. There is 21.11% increase in compressive strength, 12.87% increase in density, 76.66% decrease in linear shrinkage and 11.27% decrease in water absorption compared to the control.

Hence, 5%SDA + 30% IOT can be recommended for use in improving the strength of burnt clay brick.

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