Impact of Varying Laterite and Cowhorn Additives on The Mechanical Properties of Cement Matrix Plastic Tiles

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Abstract-
The transition to sustainability to meet human needs through the use of animal waste obtained from anthropogenic activities has become a subject of global importance in recent times because of its ability to preserve our environmental life support systems. This work focused on utilizing laterite and cow horn as additives in cement matrix-plastic tile production. The quantity of cement, sand and plastic used for the production was kept constant while laterite and pulverized cowhorn was varied. Produced sample dimensions were 15 mm thickness with face measurement of 150 x 150 mm. Laterite was thoroughly mixed with sand, plastic, cowhorn and cement with a known volume of water in a clean container. The resulting mixture was subjected to a compaction pressure of 25KN to obtain a cohesive material and then fired in an oven at 2200C for thirty-three minutes. After firing the sample was allowed to cool down and then subject to physico-mechanical tests. The results obtained showed that on the flexural and compressive strength of the sample containing 45% laterite and no cowhorn had best values of 11.38mpa and 0.0037Mp respectively. The water absorption and shrinkage test for the 45% laterite no cowhorn sample with 15% pulverized cowhorn and 30% laterite was the most porous. In conclusion, increasing the cowhorn content had a direct relationship with the degree of porosity, flexural and compressive strength.

Key words: Sand, laterite, plastic, tiles, pulverized cowhorn (PCH) and properties

1. Introduction
In Nigeria, foods are produced daily in large portions to meet its growing population through agricultural methods leading to the generation of agric-waste [1]. These wastes are generated from animals such as bird droppings, cow waste (hub, horns and dung) and abattoir waste. They are numerous and found around areas like the northern path of Nigeria and recently the south/west and are potentials towards achieving the sustainable development goals [2]. In the process of disposing these wastes by burning, these waste secret emissions or hazardous gasses which are harmful to human smell or can cause irritations and pose hazardous effects to the environment.

This research intends to use cow horn in a pulverized form as an addictive into the manufacturing of recycled plastic matrix tiles. Cow horn in a pulverized form can be used as raw material for the production of protein-based firefighting agent and also as a foaming agent for lightweight cellular concrete [3]. Abdullahi and salihi [4] determine the compositions cow horns as well as the mechanical properties that could be found in them. The analysis are shown in table 1
Table 1: Composition of cow horn

| S/N | Compound      | Compositions (%) |
|-----|---------------|------------------|
| 1   | Sulphur (S)   | 51.10 to 81.90   |
| 2   | Molybdenum (Mo)| 7.70 to 32.0     |
| 3   | Calcium (Ca)  | 2.50 to 8.32     |
| 4   | Zinc (Zn)     | 1.20 to 2.40     |
| 5   | Potassium (K) | 0.41 to 2.70     |
| 6   | Copper (Cu)   | 0.00 to 0.33     |
| 7   | Indium (In)   | 0.30 to 1.00     |
| 8   | Rhenium (Re)  | 1.70 to 3.20     |
| 9   | Aluminum (Al) | 0.00 to 0.78     |
| 10  | Selenium (Se)| 0.00 to 2.70     |
| 11  | Silicon (Si)  | 0.00 to 0.33     |

The reaction of pulverized cow horn mixes with the presence of Sodium in the sand and clay mixture can be substituted by Potassium found in the pulverized cow horn, Magnesium and barium would be replaced by Calcium, formation of Calcium oxide replaces Sodium Oxide, and Silicate Oxide replaces by chromium Oxide, there would be a decrease in the surface tension of the tiles which would promote coating [5]. Afolalu, et al [6] also explained that the utilization of natural occurring carbonates decreases the cost of chemical energizer and would also decrease the pollution in the environment, furthermore, stated that researches into cow bone could be utilized as cow bone produces better hardness.

Tiles are most times used in different parts of building; they are seen on internal walls and external walls, as art galleries in church building, and mostly on the floor of halls and factories [7]. Tiles are around us and used by everyone. Wall tiles are versatile and popular choice for both residential and commercial projects. They are used in churches, mosques, shops, restaurants, hospitals and households. Furniture, walls, floors, roofs, floors and stoves are covered by tiles, often they are combined with other ceramic shapes like terracotta, faience and mosaic. Tiles are tin or flat architectural or embellishing items used in awning roofs, covering floors and walls. Tiles may be protracted to consist of tiny leveled pieces of surfacing material that are not ceramic, like carpet, wood, stone or cork, etc. [8].

They are mainly made up of clay or inorganic raw material in any form. The main materials used for the manufacture of tiles are silica sand, laterite or clay, cement, and additives. Previous research such as characterization and potential application of kano cattle horn [4] showed that the mechanical properties of the pulverized cow horn had an increase in the young modulus and tensile strength from an 850 MPa and 40 MPa at 19 percent water content to 2.3GPa and 154 MPa at 0 percent water content respectively which can also increase the water adsorption level and a decrease in frost resistance with the presence of the microspores found on the surfaces of tiles. Also, research into design analysis and optimization of cow horn – plastic composite chair seat investigated by Ibrahim & Muhammad [9], showed an increase in the mechanical property of the chair seat. Hence, this study tends to use the findings above to introduce pulverized cow horn which are considered waste in the environment into the production tiles by varying it with other conventional material to replace part of the cement used in tile production to see if the adhering properties as well as physico-mechanical properties of the tiles could be boosted.
2. Methodology

2.1 Pre-experimental Analysis

2.1.1 Physical properties of raw materials

Before the manufacturing of the tiles, raw materials for the tiles used were subjected to physical tests. Materials masses were obtained by weighing them on a weighing balance. Materials were then placed in a beaker with a known volume of clean water and stirred for a minute or two after which volume was obtained. The density was derived using equation 2.1. Also the sieve analysis for the sand, laterite and plastic was performed. Table 2 shows the density of silica, laterite and plastic (recycled plastic) used for manufacturing the cement matrix tiles.

\[ \rho = \frac{M}{V} \]  

(2.1)

Table 2: Density

| S/N | Material               | Colour   | Density (kg/m\textsuperscript{3}) |
|-----|------------------------|----------|-----------------------------------|
| 1   | Silica Sand            | Light Brown | 1.72                             |
| 2   | Laterite               | Reddish brown | 1.224                           |
| 3   | Pulverized cow horn    | Ash       | 0.28                             |
| 4   | Pulverized Recycled Plastic | Grey  | 0.56                             |

Figure 1 shows the sieve analysis curve for laterite, silica sand and pulverized recycled plastic. The sieve analysis was performed by placing the laboratory test sieves carefully on a mechanical sieve shaker (Associated Scientific & Engineering Works (ASEW)) to provide a linear and vertical movement to the sieve, resulting particles to bounce and turn so as to present different orientations to the sieving surface in accordance to ASTMD6913. This was done to determine the mesh size at which all materials to be used would be closely compacted when the tiles are to be manufactured. It also helps maximize usage. This showed the sieve analysis of raw materials silica, clay, laterite, recycled pulverized plastic and pulverized cow horn particles size retained 0.850mm sieve size and 0.600mm respectively. Therefore, the particles size of 0.855mm mesh size was adopted for all aggregated materials to guarantee utmost materials usage.
Table 3: Percentage variation laterite and pulverized cowhorn Additives

| s/n | Variation | Laterite % | Cement % | Silica % | Plastic % | PCH % | Compaction Load (KN) |
|-----|-----------|------------|----------|----------|-----------|-------|----------------------|
| 1   | A³5:0     | 45         | 5        | 10       | 40        | 0     | 25                   |
| 2   | B³0:5     | 40         | 5        | 10       | 40        | 5     | 25                   |
| 3   | C³5:10    | 35         | 5        | 10       | 40        | 10    | 25                   |
| 3   | D³0:15    | 30         | 5        | 10       | 40        | 15    | 25                   |

2.2 The moulding process of the sample tiles

This procedure used for the production of the tiles is similar to those used by Ohijeagbon [8]; the manufactured tiles were produced using a mild steel mould. The mould was fabricated to have a right-angle construction to a uniform thickness of 149 mm, a facial dimension of 150 mm x 150 mm and a height of 80mm. The materials used were laterite, silica sand, Dangote cement (x3) and clean water. Cement was used as a binder while silica sands as the stabilizer and plastic the addictive. Each batch ratio mixture was stirred thoroughly for about two to four minutes to maintain a uniform mixture after which water was added and stirred thoroughly to remove lumps and achieve a homogenous mixture. The mixture was then placed in the square mould, to avoid producing a rough pattern tile, nylon was placed over the mixture to avoid friction and the material sticking to the mould. Thereafter a punch of 25KN was incorporated and applied to produce the tiles. The produced tiles were pressed in the mould to a uniform thickness of 14 mm; the process for fired tiles was concluded by placing the pressed homogenous mixture in an oven for 35 minutes while the unfired batches were placed under room temperature and cured for 7 days.
2.3 Physical properties tests for sample tiles

2.3.1 Determination of water absorption (WA)

In order to determine the capacity of the tile to absorb, each tiles sample was weighed to obtain dry mass before immersion. Tile sample were then immersed for 24hrs, after which the samples are retrieved, and its surfaces cleaned off with a dry cloth to remove moisture from the surface of the tiles. Thereafter, tile samples are then weighed again to determine the soaked mass. Equation 2.2 was then used to determine percentage water absorbed.

\[
\%WA = \frac{Wet\ Mass - Dry\ Mass}{Dry\ Mass} \times 100
\]  (2.2)

2.3.2 Determination of water shrinkage

The water shrinkage percentage was obtained by retrieving tile samples from the water tank and allowed to dry for 24 hours at room temperature. The weight was than obtained after 24 hours. The recorded value was then inserted in equation 2.3 to obtain percentage water shrinkage.

\[
\%WS = \frac{Wet\ mass - dry\ mass}{wet\ mass} \times 100
\]  (2.3)

2.4 Mechanical properties tests of Batch samples

2.4.1 Flexural strength

The flexural strength test was performed according to those used by Ohijeagbion et al [10]. The expression in equation 2.4 was used by inserting load \( P \) (N), distance \( L \) and thickness \( T \) of the specimen tested (mm) at rapture.

\[
M = \frac{8PL}{\pi T^3}
\]  (2.4)

Where \( M \), modulus of rupture (MPa)

2.4.2 Compressive strength

The compressive strength test was performed according to those used by Ohijeagbion et al [10]. Equation 2.5 was used by inserting average load on the specimen at failure \( P_c \) (N) and area of the bearing surface on the test specimen \( A_c \), (mm2).

\[
C_s = \frac{P_c}{A_c}
\]  (2.5)

Where, \( C_s \) = Compressive strength of the specimen, (MPa)

3. Result and discussions

3.1 Physico-mechanical properties of batch sample of tiles

3.1.1 Water absorption

Figure 2 is the water absorption test result for the experiment. It shows that the laterite:pulverized cow horn with 45:0 had the lowest water absorped. It also shows that as laterite increases, the percentage water absorbed reduced and vice versa and as pulverized cowhorn increased, percentage water absorbed increased and vice versa.
3.1.2 Sample Shrinkage
Figure 3 is the percentage water shrinkage for the test samples. It shows that an enormous amount of water was retained by each tile sample. Also, no particular trend was obtained as the 45:0 of laterite:PCH recorded the lowest percentage water shrinkage when subjected to 24 hours dry period, thereby making the tile samples porous and less durable.

3.1.3 Flexural strength
Figure 4 shows the flexural strength for the test samples. It was observed that the highest flexural strength was recorded at 11.380 Mpa when laterite:PCH ratio was 45:0. The flexural strength decreased as laterite decreased and vice versa.
3.1.4 Compressive strength

Figure 5 is the compressive strength for the test samples. The compressive strength of in Figure 5 indicates that the best compressive strength was recorded when the mixture ratio was 35:10.

4. Conclusion
The cement matrix plastic tiles were produced by varying laterite and pulverized cow horn; samples were fired for 35 minutes while the unfired batches were placed under room temperature and cured for 7 days to determine their physico-mechanical test. The following conclusions could be drawn from the study:

- the unfired tiles were friable to undergo physico-mechanical test,
- the water absorption and shrinkage test for the laterite:PCH samples with 30:15 percent was most porous. It was observed that increasing the PCH content had a direct relationship with the degree of porosity and vice versa,
- it was also observed that the flexural strength of the samples containing 45% laterite and no PCH recorded the best values of 11.38 mpa, thus a direct relationship between the PCH and vice versa.
- the compressive strength of samples were best recorded at 0.0037 Mpa and did not follow particular trend for the compressive strength.

5. Recommendation
It is suggested that the quality of cement used for the unfired samples could be slightly increased to investigate its effect on the physic-mechanical properties of cement matrix tiles.

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