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EVALUATION OF CLAY ROOF TILES PRODUCED WITH MAKUBA AS A BINDER

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Building materials is beyond the affordability of the medium/low-income group of the society. This has become a huge challenge because of the huge capital outlay required to do so. Thus, acquisition of indigenous roof tiles using laterite, saw dust and makuba as binder has being suggested to reduce the cost of building material by 50%. The aim of this study is to determine the suitability of clay, saw dust and makuba as binder in the production of roof tiles for use in low cost building construction. Clay was the primary material; Laterite was added to reduce shrinkage; saw-dust serves as a filler to reduce the density of the roof tile. Makuba was used as a binder in the mix matrix. Absolute volume method of mix proportioning was adopted in the design of the mix. The water/binder ratio used in the production of all the clay roof tiles was 0.7. The methodology adopted was by means of laboratory test through which primary data was obtained. Preliminary tests such as specific gravity and bulk density tests were conducted on clay, sawdust and Makuba. Physical and mechanical properties such as water absorption, abrasion resistance and flexural strength test were equally undertaken on the clay tiles. Indoor curing was adopted for all the clay roof tiles. Findings revealed that the Abrasion resistance result indicated that 2.5% Makuba clay roof tiles produced in this study have higher resistance to abrasion. The best result in terms of water absorption is 2.5% Makuba clay roof tile with the percentage weight gain of 1.41%. Finally, Finding also revealed that flexural strength of clay roof tiles made with 2.5% Makuba meet the average failure load of 498N as specified by BS 47390(1967.) The study therefore concluded that the performance of Makuba at 2.5% is satisfactory on clay roofing tiles products for discontinuous laying on pitched roofs.

Keywords: building materials, clay roof tiles, makuba, sawdust.

INTRODUCTION

The building materials sector is a major contributor to the construction industry of every nation because materials constitute the single largest input in construction often accounted for about half of the total cost of most or any construction project, (Baiden et al, 2014). According to Abiola (2000), building materials is one of the principal factors affecting the effective performance of the Nigerian construction

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industry. This means that access to decent accommodation in Nigeria will continue to be elusive until the scarcity and prohibitive cost of conventional building materials and components are checked (Njoku, 2012).

The strategy of developing more sophisticated building materials has benefited mainly the modern, and to lesser extent, the conventional building sector, e.g. government construction and the more affluent sections of urban and rural population (Food and Agricultural Organisation, 1993). One could possibly also say that, the more affluent section of the population builds houses which last and appreciate in value while the poorer population builds semi-permanent or temporary shelters that require continual repairs and maintenance and appreciate much less, if at all in value (Spence and Cook, 2007). A large number of housing experts believe that local building materials serve as good alternative in housing construction and that the use of them will go a long way in ameliorating the shortage of housing in developing countries thereby reducing importation and cut down the overall cost (Omole and Bako, 2013).

Furthermore, roofing materials constitute an essential element in housing delivery. It is estimated that it covers about 50% of the total cost of a building. The choice of roofing material is a function of cost, availability of material, durability, aesthetics and climatic condition (Barry, 1996). The importance of housing in human history cannot be overemphasized. Housing is seen as one of the best indicators of a person's standard of living and of his or her place in society (UNCHS, 1993). Furthermore, Reddy (2004) is of the view that housing and building conditions also reflect the living standards of a society.

Roofing sheet is one of the most popular conventional materials for most construction works. Thus any change in its price portends significant effects on the total cost of construction (Abubakar, 2010). In order to reduce over dependence on conventional building materials, especially long span roofing, cement, ceramic etc researchers have been intensified on the use of locally sourced materials as an alternative materials that can be used to replace these conventional materials. This has led to various researches into development of locally available building materials and construction techniques to enhance access to housing for all (Abubakar, 2010). Research conducted by Oyekele and Bankole (2000) on construction of roofing tiles using coconut fibres. The research findings revealed that low average shrinkage values was obtained at 2.30% replacement which shows thar coconut fibres is satisfactory for producing roofing tiles.

Also, research conducted by Opara (2011) on the production of ebonite roofing tiles using rice husk, marble dust pulp, cement and water in appropriate proportion. The research compared this roofing tile produced with asbestos roofing tiles. The results indicated that the mean compressive strength at 28 days is obtained as 13N/mm2 which is satisfactory in accordance with BS 1191, 6463: Part 4 and ASTM 204. Therefore, this tile is cost effective, strong, maintenance free and resistance to corrosion and heat. It is against this back drop that this study evaluate the tendency of producing clay roof tiles using makuba as binder.

LITERETURE REVIEW

Clay roof tiles

A roof is an essential component of a dwelling and is critical to shelter and privacy. In many developing countries in which Nigeria is not exempted, roofing alone represents about 50% of the total construction cost of low cost houses. As the name implies, most roofs for low cost houses are constructed using low cost and the indigenous materials such as thatch of unfired clay which have poor durability and can be hazardous to both health and safety. Moreover, such materials can be dangerous during fire outbreaks, windstorms, earthquakes and other disasters. To provide more permanent roofing materials, many developing countries have been spending a lot on importation of corrugated Aluminum and asbestos cement roofing sheets. These materials are often too costly for most people in developing countries and hence do not solve the roofing problem, it has also be found that asbestos fibre is dangerous to health because the fibre is cancerous and has led to death of many people in developing countries William, (1981).

The special advantage of using clay roof tiles is the authenticity and the historical longevity and time proven track record. Nothing matches the classic look of real clay tiles. Concrete Roof Tiles are only pretending to look like clay tiles, but often can't match the natural colour blends and style of clay tile roofs, Euro-Tech Construction, (2010).

Previous research on production of roofing tiles using local materials

The study conducted by Khalil (2005) on stabilization of clay using cassava starch as a binder. The study used 2.5%, 5%, 7.5%, 10%, 15%, 20% and also 0% as a control as a percentages of clay with cassava starch by weight. The findings revealed that 15% replacement had the less water absorption of 25% as compared with other percentage replacements. Also, higher values of compressive strength of 1.88N/mm2 is recorded at 15% replacement. This implies that the optimum replacement level of cassava starch as a binder in clay is 15%. Similarly, Oyeleke and Bankole (2000) investigated the use of natural fibres an agricultural residue in the production of roofing tiles. The results revealed that the strength values obtained using these natural fibres had better strength than the roofing tiles produced with conventional construction materials.

Furthermore, Opara (2011) undertook a study for the production of ebonite roofing tiles using rice husk, marble dust pulp, cement and water in appropriate proportions. The study compared the roof tiles produced with these materials with asbestos roofing tile sheets. The research revealed that mean compressive strength of specimens obtained is 13 N/mm2 this value satisfied BS 1191, 6463 Part 4 and ASTM 204 requirement. In addition, Maminat (2001) undertook a study on production of plain concrete roof tiles stabilized natural materials. The finding from the study showed that the average breaking load due to flexure failure at 28 days is 562N which is more than 498N specified by B.S 473:1967:Part 1. Also, the results of water absorption averagely was 10.13% which indicates that the tiles has the tendency to absorb water in moist environment.

STATEMENT OF RESEARCH PROBLEM

Housing delivery in Nigeria today is associated with numerous problems which includes cost of construction materials, high demand for housing and lack of promotion of the use of locally and naturally available material (Dashan and Nwankwo, 2000 and Lawal, 1999). These may be attributed to lack of practical knowledge on the applications of locally available materials.

Government and private sector designs lay serious emphasis on the traditional building materials (i.e. cement, steel, gravel, sand etc). These materials are either imported or the machinery to produce them is imported. The cost of the materials is made exorbitant by the attendant imported inflation, handling and hauling costs and overhead charges.

JUSTIFICATION OF THE STUDY

Roofing tiles are mostly imported into the country which makes it scarce and highly expensive due to cost of shopping, clearing and transportation to site Dashan and Nwanko, 2000). It is necessary therefore to seek ways of manufacturing roofing tiles using our available local materials such as clay and sawdust which are available and have been considered as waste products.

If these waste products are judiciously utilized, it will help in reducing the cost of roofing sheets which will cut- down construction cost thereby making housing affordable to common citizens. The outcome of the study will propagate the use of these wastes which are hitherto dumped as waste and create addition to the inventory on consumable raw materials in Nigeria. The study will open a new vista of opportunities in the utilization of local clays for the production of roofing tiles for residential, educational and commercial buildings in Nigeria.

MATERIALS AND METHODS

Materials

The materials used for this experimental study includes clay, sawdust and makuba as a binder. Physical property tests on these materials were conducted to determine their physical properties like; specific gravity and bulk density.

1. Clay

The clay used in this work is obtained from Duku river side, Birnin kebbi, Kebbi State, Nigeria and is dark in colour, it is collected from the depth of about 0.75m depth from the ground level. The clay is actually the primary material used in this study its widespread use is mainly due to the availability of it in most countries.

2. Saw Dust

Saw-dust are grained of wood formed when wood are sawn to various sizes for the purpose of building and other civil engineering construction work. The particle size depends on the cutting machine blade used. It is classified as one of the light weight material due to its lightness in nature. The saw dust is introduced into the roof tile matrix to reduce the weight of clay and laterite as the primary materials and hence enhance the light weight property of the roof tiles. The saw-dust used in research was obtained from saw mill in Kara Market in Birnin kebbi Local Government Area of Kebbi State, Nigeria.

3. Makuba (Parkia bioglobosa)
The African locust bean tree, Parkia biglobosa is a perenial tree legume which belongs to the sub-family Mimosoideae and family Leguminosae. It grows in the savannah region of West Africa up to the southern edge of the Sahel zone 130N (Campbell-Platt, 1980). These trees are not normally cultivated but can be seen in population of two or more in the savannah region of Nigeria (Schnell, 1957: Hopkins, 1983). The Parkia tree plays vital ecological role in cycling of nutrients from deep soils, by holding the soil particles to prevent soil erosion with the aid of roots. The trees also provide shades for farmers (Campbell-Platt, 1980). Parkia tree is used as timber for making pestles, mortars, bows, hoe handles and seats (Hagos, 1962; Irvine, 1961). The trees of the Parkia species are usually and carefully preserved by the inhabitants of the area where they grow because they are valuable sources of reliable food, especially the seeds which serves as source of useful ingredients for consumption (Campbell- Pratt, 1980). It has been reported that the husks and pods are good food for livestock (Douglass, 1976), Husk of Makuba (Parkia biglobosa) used in this research work was obtained from Zuru, Zuru Local Government area of Kebbi State, the husk was grounded to pounder form. The husk is shown on Plate 1.0

PLATE 1.0: Husk of Makuba

Methods
Preliminary tests such as specific gravity and bulk density test were conducted on clay, sawdust and Makuba. Also, tests like water absorption, abrasion resistance and flexural strength test were equally carried out on the hardened Clay roof tiles.

Preliminary tests conducted on research materials
1. Specific gravity test
The specific gravity of material is defined as the ratio of the weight of a given volume of that material to the weight of an equal volume of water. The specific gravity test was carried out in accordance with ASTM D 2395-83. Five trial samples were tested for clay, sawdust and makuba and average value was obtained for each material. These values were used in calculating the quantity of the materials to use in the production of clay roofing tile.

2. Bulk density test
This test was considered as loose and compacted bulk density. For compated bulk density, measurement involves filling the cylinder in three layers each layer being compacted with a metal rod for twenty five 25 times before adding the next layer.

The procedures are the same for clay, sawdust and makuba. This test was carried out in accordance with BS 812:Part 2:1997.

Mix Proportioning of Materials

The mix proportion was conducted in accordance with BS 1377, (1990) aimed at determining the proportion of materials in each specimen. The materials are clay, laterite, saw- dust, Makuba, and water. The materials were calculated by absolute volume method.

The Clay roof tiles were produced in the laboratory using clay with binder replacement level of 2.5%, 5%, and 10%. Also, 0% binder replacement level was produced to serve as a control. The clay tiles were prepared and tested after 28 days curing periods. Indoor curing was adopted. The water/binder ratio used in the production of the tiles was 0.7.

Tests conducted on hardened Clay roofing tiles

1. Abrasion Resistance Test

This test assessed the level of resistance of particles surface to wear. The apparatus as for this test are weighting balance and wire brush. This test was conducted in accordance with Testing and Method C 1167: Part 1: (2011).

2. Water Absorption Test

This test was conducted in accordance with ASTM C70 – 79. The suitability of this tile aim at avoiding high water absorption, Tests were carried out by immersing the tile in water for a period until it stops bubbling. The apparatus are water tank and weighing balance. This test is important in determining the water absorption rate of the tiles.

3. Flexural Strength Test

This test was performed as described in BS 538: 1994. The roof tile was placed on two lower bearers the first bearer is in the position normally occupied by the batten; the second bearer is separated from the first by a distance equal to two thirds of the overall length (L) of the tile as shown in Plate 2.0 The load application bar is placed parallel to the two lower bearers and equidistant from each other. Apply the test load progressively at the rate of about 20kg until the sample fails as shown in Plate 2.0.

Plate 2.0: Makuba clay roof tile under progressive loading for flexural strength test

RESULTS AND DISCUSSION

Results of Specific Gravity and Bulk Density of Materials

The result obtained shows that; the clay has an average specific gravity of 2.0, while that of laterite is 2.6, that of saw-dust is 1.1 and that of Makuba is 0.86. The specific gravity test results of saw-dust and that of Makuba shows that the materials are light in weight. Similarly the result of bulk density also indicates that the Sawdust and Makuba are less dense than clay.

Table 1: Specific Gravity and Bulk Density of Materials

Materials	Specific gravity	Bulk Density Kg/m^3
Makuba	0.86	604
Saw-dust	1.1	219
Laterite	2.6	1481
Clay	2.0	1575

Source: Experimental work, 2018

Results of Abrasion Resistance

The Abrasion resistance results as shown in Figure 1.0 indicates that the weight loss of roof tiles made of 2.5% Makuba has high abrasion resistance of which the percentage weight loss is 0.35%. This is followed by the weight loss of 5% Makuba which has the percentage weight loss of 0.98%. The least in performance in terms of abrasion resistance is the tiles produced with 10% makuba binder replacement, with the percentage weight loss of 3.125%. This implies that as the percentage binder level (Makuba) increases the abrasion resistance decreases. Thus, 2.5% replacement had the least values of percentage weight loss (abrasion resistance).

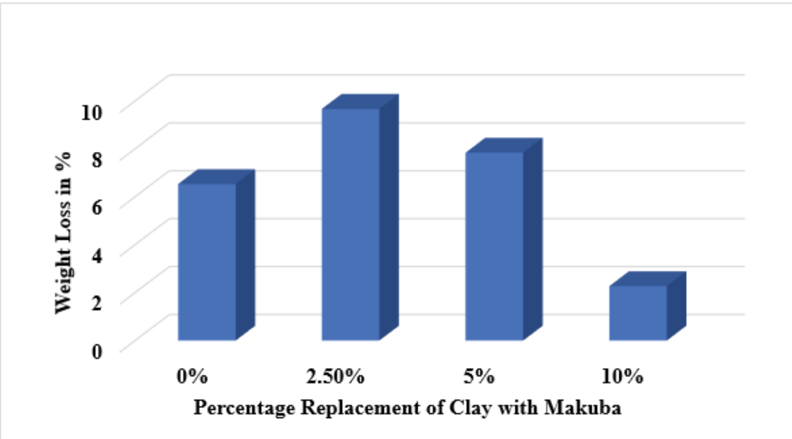

Figure 1.0 Relationship between Weight loss in % (Abrasion Resistance) with Percentage Replacement of Clay with Makuba

Results of Water Absorption

The result of water absorption shown in Table 2 indicates that the water absorption of clay tiles with binder replacement level of 2.5% Makuba is 1.41%, At binder replacement level of 5%, the water absorption of Makuba is 3.13%, At 10% binder replacement level, water absorption is 14.78% This implies that as the percentage binder level (Makuba) increases the water absorption also increases. Therefore, the optimum percentage replacement is 2.5%.

Table 2: Result of Water Absorption

% Level	Makuba Wb (g)	Wa (g)	Wg (g)	% Wg (g)
0%	2680	2840	160	5.97
2.5%	2840	2880	40	1.41
5%	2560	2640	80	3.13
10%	1760	2020	260	14.78

Source: Experimental Work, 2018.

Wb = Weight before, Wa = Weight after,

Wg = Weight gain and

%Wg = Percentage weight gain

Result of Flexural Strength

From the results shown in Figure 2.0 the average failure load of clay roof tiles at 2.5% Makuba prove to be the best with average failure load of 37Kg and flexural strength of 9.67N/mm2. The results obtained of flexural strength of 2.5% Makuba clay roof tiles (9.67N/mm2) is slightly close to the flexural strength of plain roof tiles (14.06N/mm2) produced using cement, fine aggregate and water. Maminat (2001). The next in strength is 5% Makuba with average failure load of 30Kg and flexural strength of 7.8N/mm2.

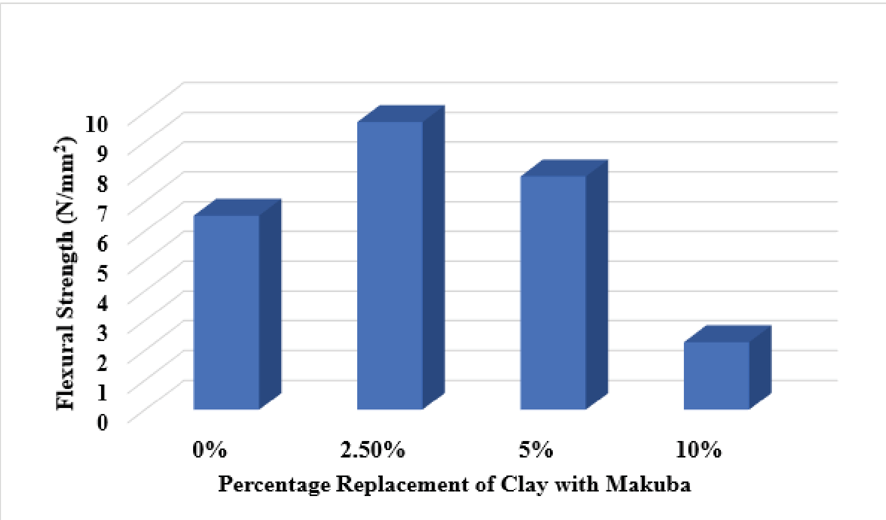

Figure 2.0 Relationship between Flexural Strength and Percentage Replacement of Clay with Makuba

CONCLUSIONS

The research work entails evaluation of Clay Roofing Tiles Using Makuba as a Binder. Therefore, the study allows the followings conclusions to be drawn:

1. The roofing tiles made with 2.5% replacement of clay with makuba has the least values of water absorption. This means 2.5% consume less water than control and other percentage replacements.
2. At 28 days, specimen with 2.5% replacement of makuba gave highest abrasion resistance than control and other replacements. This implies that to improve abrasion resistance of clay roof tiles makuba ha to be added to 2.5% replacement to clay content.

3. The high flexural strength value was recorded at 2.5% replacement. This means that the optimum replacement level of clay with makuba in the production of clay roof tile is 2.5%.

However, the following constraints posed a big challenges to the researchers in the course of experiment:

1. Lack of standard compacting matching machine to compact the mixed materials after it has been poured in the mould. As such manual compaction was adopted.
2. Wooden moulds were used in the casting of the specimens. This is because of lack of standard roofing tile mould in the market, therefore wooden moulds were formed and used for the experiment.

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