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COMPARATIVE PERFORMANCE ANALYSIS OF FIRED CLAY BRICKS AND QUARRY DUST SANDCRETE BRICKS

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Abstract - *The objective of this research is to analyze and compare the performance of fired clay and quarry dust sandcrete bricks, produced locally, because, building's cost has risen which necessitate the Nigeria to utilize its local building materials and technologies in meeting the housing needs Therefore, this research utilizes an alternative means of producing fired clay brick using quarry dust, sand with 0, 50 and 100% replacement and using cement mix ratios of 1:6. The quarry dust sandcrete brick produced was compared with the fired clay brick produced in local markets based on compressive strengths and water absorptions properties and thus the findings shows that the quarry dust sandcrete brick produced with 100% replacement at a 28days of curing is able to replace the fired clay brick. However, the study does not cover the economy in producing the two bricks, the availability of producing materials, the fire resistivity, efflorescence property, aesthetic features etc. which can further be studied separately.*

Keywords*: *Performance, Comparison, Building, Produced, Replacement

1. INTRODUCTION

The level of building cost has made it necessary for Nigerian community especially in rural areas to utilize its locally produced building materials in meeting the shelter needs of low- and mid-income earners. the housing sector is faces with a critical challenge where the demand for housing cannot be met by the current efforts. Brick is strong, durable, and aesthetically pleasing; it can be made from materials found widely across Nigeria. To add to the mystery of its lack of uptake in the market, it actually costs less to build with brick than with block. Traditionally, brick referred to a building unit which composed of clay, soil, sand, and lime but it is now used to denote any rectangular units lay in mortar and it has some distinct characteristics and advantages which makes it have an edge over the other walling material. Bricks are normally manufactured in different classes, types, materials, and sizes which vary with region and time period, and they can be produced in larger or smaller scale. The emergence of new building materials and new methods of constructions has made the Bricks to become obsolete. Despite its relative cheapness, availability, low cost of both construction and maintenance. Others are its simple method of construction, aesthetics and its thermal insulation at extreme weather conditions etc.

This research is intended to compare the strength properties of fired clay brick with quarry dust sandcrete bricks and the suitability of replacing one with the other. This will enable any engineer who is willing to use bricks for a construction project to choose the best among the two that will suit his strength requirement; this will result in minimizing the cost of the entire building, and thus achieve the desired strength at a minimum cost. The findings of the study would help the individuals to produce more durable alternative bricks for building affordable, strong, and durable houses for the society members. The communities would re-discover more alternative construction materials using available materials within their domain as a result this finding. This would help in reducing over dependency on Sandcrete blocks which is not within the reach of the low- income earner. walling unit is the most significant component of housing development. Therefore, materials to be used for building construction must provide objective evidence of quality and cost effectiveness in terms of functional requirements and low-income economy respectively.

2. NEED FOR THE RESEARCH

The main challenge that construction industries faced is lack and unavailability of raw materials, this might happen due to abandoned the use of traditional building materials, most especially fired clay bricks which have been in existence long ago. This has impacted negatively to the economy of the nation at large; it raised the cost of acquisition of building by both private and public sectors. However there has been very little or no relevant information about the manufacturing standard and the quality of these locally made bricks here in Nigeria as compared to other countries, hence it is the aim of this study to provide some of the information about the compressive strength properties of the locally produced Fired clay bricks as compared with the quarry dust sandcrete bricks, and the suitability of replacing one with the other.

3. AIM AND OBJECTIVES

3.1: Aim

This research aimed at analyzing the performance of fired clay bricks produced locally by various manufactures with quarry dust sandcrete bricks.

3.2: Objectives

The main objectives of the study are:

i. To produce samples of quarry dust sandcrete bricks
ii. To determine and compare the strength of fired clay bricks with quarry dust sandcrete bricks produced
iii. To determine whether the produced sandcrete bricks will be able to replace the local clay bricks produced by various manufactures, in terms of compressive strength and water absorption.

4. SCOPE AND LIMITATION

4.1: Scope of the Study

the compressive strength of these various fired clay bricks and that of quarry dust sandcrete bricks will be used to assess the strength performance of the two, and the ability of the replacement based on the results.

4.2: Limitation of the Study

The study is limited to analyze compressive strength and water absorption properties of the fired clay bricks and quarry dust sandcrete brick only, other properties such as weather resistance, fire resistance, etc. are not covered.

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5. LITERATURE REVIEW

A broad-based definition of Laterite which may be more approach to engineering practices, which was suggested by [1] described it as "any the reddish deposited or non-deposited tropically weathered soils, which genetically form a chain of materials ranging from decomposed rock through clays to rich crust, generally known as cuirass or carapace". [2] describes laterite as heavily leached tropical subsoil which is not beyond the agricultural purposes and mainly made up of iron and aluminum oxides and kaolinite-clays. Africa is a continent full minerals resources deposited uniformly at different location and luckily Nigeria has minerals which include laterite materials suitable for local utilization. but unfortunately, the construction sectors are standstill in making optimal utilization of such resources [3]. Inaccessibility and incapability to afford both modern material and method of construction financially by some communities especially villages in Nigeria, necessitate them to keep using mud and clay materials as the alternative for long period of time. Despite that there are no any existing guidelines that they usually adopt for constructions with such materials. Therefore, it brings problem such as flooding potential, unnoticed collapse etc. Especially in a swarm area [4]. According to [5], The qualitative output and cost of construction materials are among the major factors that affect the choice, type and usage of housing projects in Nigeria. [6], viewed that brick earth is made by uniform the disintegration of igneous rocks and that a good brick should be easily moulded and dried without cracking and warping. To achieve this the chemical composition, Total content of clay and silt is recommended to preferably be less than 50 percent by weight. [6] further stated that brick earth must have proper proportions of sand, silt and clay; be homogeneous; have sufficient plasticity and be free from lumps of lime. It was used for weathering materials from which bricks are cut, that after drying are used as building bricks. [7].

The compressed stabilized earth bricks show proven performance in term of strength characteristics which can be used for multiple purpose such as load bearing walls for multi storey buildings [8] From the model developed by [9] using augmented scheffe's simple lattice design a mix proportion, water absorption and compressive strength up to 2.56N/m^2 of laterite quarry dust cement block can be predicted. The use of stabilized compressed earth bricks is advantageous over clay bricks as it provides less cost of production, minimizing environmental pollution and its associated reduced cost of transportation due to its abundance. [10] According to research conducted by [11], claimed that the rate of water absorption by the sandcrete depends on the pore spaces between the particles i.e. the large the spaces the higher the water to be absorbed, this is because the sand particles are smaller and contain high amount of silt that absorb much water which affect the strength properties of sandcrete block.

6. MATERIALS AND METHODS

6.1: Materials

i. **Fired clay Bricks:** Fired red clay bricks used in the study was purchased from two different manufacturers.
ii. **Sand:** Sand used for the test was obtained from River Wudil, Kano state
iii. **Cement:** Ordinary Portland cement (Produced by Dangote cement) was purchased from the open market in Wudil town.
iv. **Water:** Portable tap water was employed in the laboratory tests conducted.

v. **Quarry Dust:** The quarry dust was obtained from H&M Construction Company's quarry site at Dawakin kudu L.G.A of Kano state.
vi. **Colour Additive:** Reddish brown colour was purchased from the market.

6.2: METHODS

6.2.1: Methodology Employed in the Production of Quarry Dust Sandcrete Bricks

The quarry dust-sand-cement mixtures for specimens were prepared by thoroughly mixing predetermined quantities of air-dried quarry dust, sand and Portland cement using a mix ratio of 1:6, until a uniform colour was obtained. Thereafter an amount of water necessary to give the required moisture content was added to the dry mixtures. Specimens were cured in a water bath for 7, 14 and 28 days. Sandcrete bricks were produced using quarry dust-sand-cement. And the replacement of the sand with quarry dust by 0%, 50% and 100% respectively. Sand was air dried for 24 hours before passing them through 5 mm sieve. Particles passing through the sieve were used for brick production. Cement and sand were mixed together then the quarry dust and colour additive were added to the mixture. Thereafter water was added and mixing continued until a homogeneous mix was obtained. Trial mix results showed that water to cement ratio of 0.56 gave the best result, hence this ratio was used for brick production. The produced bricks were placed in a water bath and left to cure for 7, 14 and 28 days. A Series of compressive strength tests were then performed on the 9 various bricks samples for each respective curing date.

6.2.2: Laboratory Tests for Quarry Dust Sandcrete Bricks

For the purpose of this research, laboratory tests were conducted to determine the properties of the bricks and that of the constituent materials for the quarry dust sandcrete bricks, the tests include;

i. **Sieve Analysis** in accordance with [12]
ii. **Specific Gravity** in accordance with [13]
iii. **Moisture Content** in accordance with [14]
iv. **Bulk density** in accordance with [15]
v. **Water Absorption** in accordance with [16]
vi. **Compressive Strength Test** in accordance with [20].

6.2.3: Methodology Employed for The Various Fired Clay Bricks

The fired clay bricks were purchased from two various local manufacturers, five samples of the bricks from each manufacturer were selected as the specimen for the test; the bricks are then inserted in to a water bath for 3days. After 3days, the samples were removed from the water bath and allowed to dry at a room temperature; the samples were then named from A-E. The sizes and weight of each sample were measured respectively.

6.2.4: Laboratory Tests for Fired clay Bricks

For the purpose of this research, laboratory tests were conducted to determine the properties of the fired clay bricks purchased, the tests include;

i. Water Absorption Test
ii. Compressive Strength Test

i. Water Absorption Test [16]

Absorption test is conducted to determine the amount of moisture content that the brick absorbs. If the bricks absorb more than 20% of the weight of dry brick, then the brick should not be used for construction as they absorb water from the cement mortar reducing the overall brickwork strength. In this test 3 bricks were taken from the sample and dry weight of each brick is taken M1. Weights are again recorded after fully immersing the bricks in water for 24 hrs as M2. Water absorption is calculated based on these weights.
The percentage of water absorbed W is then calculated from the relation below;

$$W = \frac{M2 - M1}{M1} \times 100 \ldots\ldots (1)$$

ii. Compressive Strength Test

The compressive strength of the fired clay bricks was determined by crushing of the various 5 samples from each manufacturer respectively, this was carried out on all the bricks. Using the relation below.

$$Compressive\ Strength\ (N/mm^2) = \frac{Maximum\ load\ at\ failure\ (N)}{Cross\ sectional\ Area\ (mm^2)} \ldots\ldots\ldots (2)$$

7. RESULTS AND DISCUSSIONS

7.1: Properties of the materials used in the quarry dust sandcrete brick production

The summary of the material properties used for the quarry dust sandcrete brick production is given in table 4.1 below.

Table 7.1: Material Properties of The Quarry Dust Sandcrete Brick

Parameter	Sand	Quarry Dust
Fineness modulus	2.78	2.93
Specific gravity	2.65	2.77
Moisture content	4.81%	0.75%
Bulk density	1531 kg/m^3	1360.6 kg/m^3

7.2: Specific Gravity

The value for the specific gravity of the sand and the quarry dust as it relates to their densities and their ratio of volume help to determine the respective amount of each sand and quarry dust that can be measured, the specific gravity of the sand and quarry dust is 2.65 and 2.77 respectively. This is within the average range for specific gravity for the sand and quarry dust which is between 2.40 to 2.80 [13].

7.3: Moisture content

The result of moisture content carried out shows a moisture content of the Sand and quarry dust collected to be 4.81% and 0.75% respectively. These indicate that the moisture content of the soil fell within 0 to 5% allowable moisture content in natural aggregate [14].

7.4: Bulk Density

The values of the bulk density of the sand and quarry dust are 1531 kg/m^{3}and 1360.6 kg/m^3 respectively. These indicate that they are good for the production of the bricks in accordance with the [15].

7.5: Sieve Analysis

The sieve analysis carried out shows that the sand and the quarry dust are well graded which is suits the production of the bricks. Sample collected satisfied the overall grading limit according to [12] and is therefore suitable for the brick production.

The graph of cumulative per cent passing (%) against sieve size (mm) is presented in figure 4.1 below.

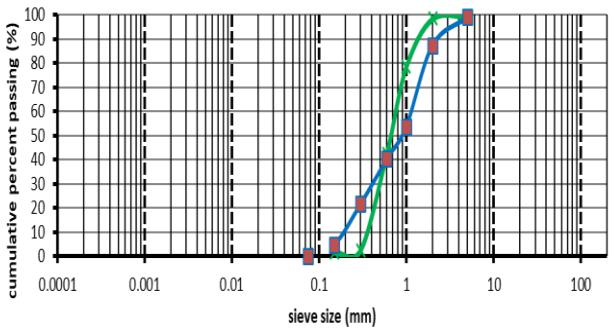

Figure 7.1: Grain Size Distribution

From the graph above
$Cu\ for\ the\ sand = 2.24$, $Cu\ for\ the\ quarry\ dust = 6.84$.
$Cc\ for\ the\ sand = 0.97$ and
$Cc\ for\ the\ quarry\ dust = 0.65$

7.6: Water Absorption

The summary of the water absorption test results for both quarry dust sandcrete brick and fired clay brick are presented below.

Table 7.2: Water Absorption Quarry Dust Sandcrete Brick and Fired Clay Brick

Bricks	Average Water Absorption (%)
Fired clay brick	14.56
Quarry dust sandcrete brick at 0% replacement	10.56
Quarry dust sandcrete brick at 50% replacement	5.60
Quarry dust sandcrete brick at 100% replacement	2.66

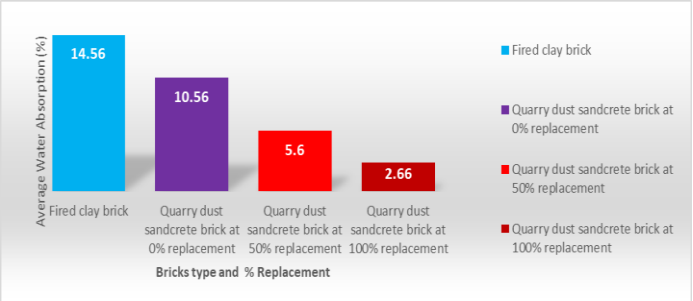

Figure 7.2: Water Absorption of Quarry Dust Sandcrete Brick and Fired Clay Brick

Water absorption influences the properties of fresh as well as hardened cementing materials. Average water absorption obtained for the quarry dust sandcrete bricks was 10.56%, 5.60% and 2.66% for corresponding replacement of 0%, 50%, and 100% respectively. While For the fired clay bricks, the result obtained from the experiment conducted shows that the average water absorption for the three various samples is 14.56%, and since it's less than 20% it indicated that the more the percentage of the replacement, the less the percentage of the water absorption, and this can be as a result of finer constituent materials contained in the sand that absorb higher percentage of water than in the quarry dust, Such that the water absorption decrease with the increment of the quarry dust. we can classify the bricks as FIRST CLASS as per as [18]. Hence the bricks can be used for various civil engineering constructions.

7.7: Compressive Strength

The summary of the experimental result for both quarry dust sandcrete bricks and fired clay bricks are presented in table 4.3 and 4.4 below.

Table 7.3: Average Compressive Strength of Quarry Dust Sandcrete Bricks

Quarry Dust Sandcrete Bricks	Average Compressive Strength (N/mm^2)		
	7days	14days	28days
0% replacement	3.24	3.76	4.48
50% replacement	5.09	5.69	6.94
100% replacement	7.86	8.39	9.81

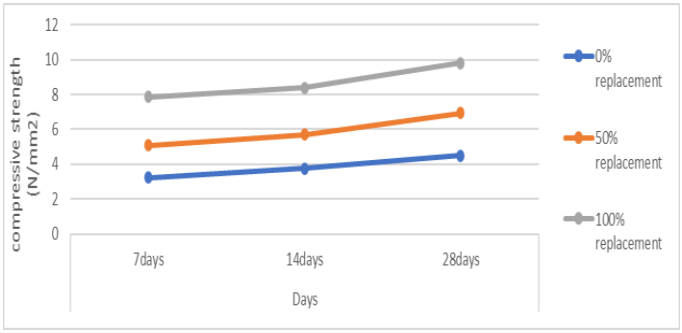

Figure 7.3: Average Compressive Strength of Quarry Dust Sandcrete Bricks

From the graphical representation above it can be seen that the average compressive strength increases with an increase in the number of curing days. It can also be seen that the compressive strength of the quarry dust sandcrete brick increases with an increase in the percentage of replacement such that at 0%,50% and 100% replacement, the compressive strengths at 28days of curing are 4.48, 6.94 and 9.81 N/mm^2 respectively. But both bricks are suitable for civil engineering works because in which all of them are greater than the minimum compressive strength of 3.5 N/mm^2 as per [17].

Table 7.4: Average Compressive Strength of Fired Clay Brick

Fired Clay Bricks	Average Compressive Strength (N/mm^2)
From Manufacture A	9.05
From Manufacture B	8.79

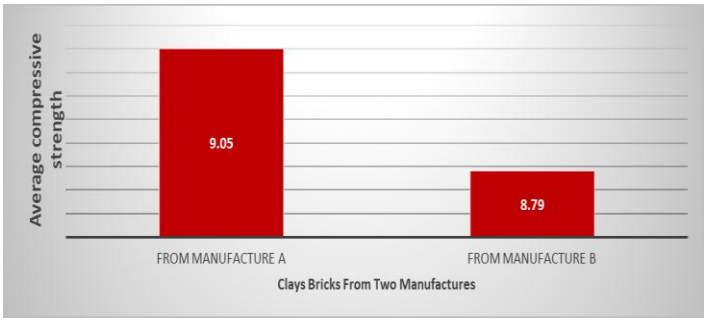

Figure 7.4: Average Compressive Strength of Quarry Dust Sandcrete Bricks

For fired clay bricks, from the experiment conducted for the five samples of bricks from 2 different manufacturers shows that both bricks are suitable for civil engineering works since the average compressive strength for the 2 manufactures are 9.05, 8.79 N/mm^2 respectively, in which all of them are between 7-14 N/mm^2 (CLASS A brick) and also exceed a minimum compressive strength of 3.5 N/mm^2 as per as [18]. Hence, those bricks can be used for any construction purposes.

7.8: Comparison between the quarry dust sandcrete bricks at 28days of curing and the fired clay brick from manufacture A.

Table 7.5: Average Compressive Strength of The Two Bricks

Bricks	Average Compressive Strength (N/mm^2)
Fired clay brick from manufacture A	9.05
Quarry dust sandcrete brick at 0% replacement	4.48
Quarry dust sandcrete brick at 50% replacement	6.94
Quarry dust sandcrete brick at 100% replacement	9.81

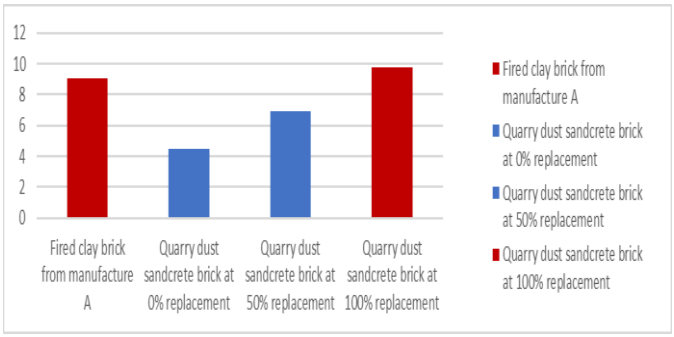

Figure 7.5: Average Compressive Strength of Quarry Dust Sandcrete And Fired Clay Bricks

From the figure 4.4 above it can be seen that only quarry dust sandcrete brick with 100% replacement can be able to replace the fired clay bricks produced by the manufacturer and since the compressive strength is between 7-14 N/mm^2 it can be considered as a CLASS (A), but both of the quarry dust sandcrete bricks at 28days of curing can be used for civil engineering construction as their compressive strengths exceeded the minimum requirement of 3.5 N/mm^2 as per as [18]

8. CONCLUSIONS

From the research work carried out, the following conclusions were drawn:

i. It was concluded that the compressive strength of the quarry dust sandcrete brick increases with an

increase in the percentage of replacement such that at 0%,50% and 100% replacement, the compressive strengths at 28days of curing are 4.48, 6.94 and 9.81 N/mm^2 respectively. While the fired clay brick's compressive strengths for the various manufactures are 9.05, 8.79 N/mm^2 respectively.

ii. Hence based on these results, we can be seen that only quarry dust sandcrete brick with 100% replacement can be able to replace the fired clay bricks produced by the two manufacturers. Although both of them (quarry dust sandcrete bricks) can be used for civil engineering construction as the compressive strengths exceeded the minimum requirement of 3.5 N/mm^2 as per as [18], also only that with 100% replacement can be considered as CLASS (A) brick since the compressive strength is between 7-14 N/mm^2

iii. The water absorption properties of the fired clay bricks are 14.56% and that of quarry dust sandcrete bricks are 10.56%, 5.60% and 2.66% for corresponding replacement of 0%, 50%, 100% respectively. Hence that fired clay bricks produced locally in the market have higher water absorption than that of quarry dust sandcrete bricks at any percentage of replacement.

9. RECOMMENDATION

The findings of the research show that only 100% quarry dust replacement brick can be used to replace the produced fired clay brick locally in the market; however, the conclusion drawn is based on compressive strength and water absorption property. its recommended that the study gab should be bridges by further research so that it covers the economic aspect in producing the two bricks, the availability of producing materials, the fire resistance properties, efflorescence property, aesthetic features among other various properties.

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REFERENCES

[1] Gidigasu, M.D. (1976); lateritic soil engineering, Elsevier scientific company New York, Pp 238

[2] Miller, R. S. (1999); "Laterite and Clay", Everything You Want to Know about Laterite www.thekrib.com/plants/fertilizer/laterama.html. accessed on 12/08/2017.

[3] Ramachandran, A. (1983); Appropriate Building Materials for Low Cost Housing in Africa, A Symposium Proceeding on November, Nairobi.

[4] Nwanga, H. A. (2005); Comparative Analysis of Quality and Cost of Sandcrete Blocks and Blocks made with Quarry Dust in Ebonyi State. Post Graduate Thesis, Department of Building, Nnamdi Azikiwe University, Awka.

[5] Akutu, G. O. (1983); Reducing the Cost of Building Project, MT Building Journal, Enugu Chika Printing Company.

[6] Rajput, R. K. (2006); Engineering Materials, S. Chand & Company Limited, New Delhi, India.

[7] Olusola, K. O. (2005); "Factors Affecting Compressive Strength and Elastic Properties of Laterized Concrete", Unpublished Ph.D. Thesis, Department of Building, Obafemi Awolowo University, Ile-Ife.

[8] C. Jayasinghe (2007), Comparative Performance of Burnt Clay Bricks and Compressed Stabilized Earth Bricks and Blocks the Institution of Engineers, Sri Lanka *ENGINEER* - Vol. XXXX, No. 022007, pp. 33-40,

[9] F. O. Okafor And E. A. Egbe (2017) "Models for Predicting Compressive Strength and Water Absorption of Laterite-Quarry Dust Cement Block Using Mixture Experiment" Nigerian Journal of Technology (Nijotech) 2017 April, Vol. 36, No. 2, Pp: 366 – 372.

[10] Sadek Deboucha and Roslan Hashim (2011) A review on bricks and stabilized compressed earth blocks Scientific Research and Essays 2011, Vol. 6 issue :3, Pp:499-506.

[11] Govind Singh Chauhan, Mahmoud Murtala Farouk, Auwal Alhassan Musa, and Lasmar Garba "*Quality Assessment of Sandcrete Blocks Produced in Kano Municipal Local Government, Kano State,"* Nigeria International Journal of Engineering and Advanced Technology (IJEAT), Volume-9 Issue-4, April 2020. Pp:706-708

[12] British Standard (BS 882:1992); specification for aggregates from the natural sources for concrete

[13] British Standard (BS 812: 1951); specification for testing aggregates

[14] . BS 812(109): 1990: specification for moisture content

[15] British Standard (BS 812: 1995); specification for bulk density of aggregates

[16] British Standard (BS 1881-122:1983); specification for water absorption

[17] British standard (BS3921:1985); Specification for clay bricks

[18] Indian standard (IS1077-1992); specification for burnt clay building bricks.

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