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EVALUATION OF PRODUCTION COST OF BRICKS USING CLAY AND STONE DUST-CEMENT

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ABSTRACT

This study aimed to investigate whether mixing clay soil, stone dust, and 5% cement could enhance strength, reduce water absorption, and lower production costs, without compromising the material's quality. Clay soil from near FUTA, Akure and stone dust from a quarry were used. Tests were conducted on the raw materials, including sieve analysis, moisture content, bulk density, and specific gravity. Clay soil was partially replaced with stone dust at 0% (control), 5%, 10%, 15%, 20%, and 25%, with a constant 5% cement. 288 bricks were produced, 144 air-dried and 144 fired at 1000°C. Compressive strength and water absorption tests were performed on both burnt and unburnt bricks. The results showed that for burnt bricks at 28 days, water absorption ranged from 11.11% to 20.00%, and for unburnt bricks, 3.33% to 7.69%. The compressive strength of burnt bricks increased up to 15% stone dust replacement, then decreased, while unburnt bricks showed a gradual strength reduction with increasing replacement. Both results met NIS and BS standards for normal building bricks.

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1. INTRODUCTION

The word bricks are used to describe a small block of burnt clay size that can be easily handled by an individual in one hand slightly longer than any other block twice its weight or width. Most bricks used in Nigeria today are made from clay, although it is possible to manufacture bricks from sand and lime or concrete. Glass bricks are scarcely unavailable in the construction industry material market in Nigeria. Bricks are a type of building material typically made of concrete, sand, lime, or clay. They are generally used to construct walls, pavement, and other types of architecture. Bricks can be produced in a variety of shapes and types depending on the materials used to make them and the use for which they are intended. It is because of their sturdiness, strength, and fire resistance, which they continue to be a popular building material [1]. According to Deboncha and Hashim, 2011, clay bricks or materials possess desirable thermal and acoustic properties and are easily obtained.

However, in Nigeria, the standard brick size is 215 mm x 102.5 mm x 65 mm. which will also be true of engineering bricks. This means the majority of bricks used in Nigeria today are made from clay, and a 10mm mortar joint is recommended, the working size 225 mm x 112.5 mm x 75 mm as shown in Plate 1, normally other bricks described as special can be manufactured to other shapes and sizes.

Clay differs widely in composition from place to place and clay dug from one part of the field may differ from that dug from another part of the same field. Clay in ground mills is mixed with water to make it plastic, this type of clay can be moulded either by hand or machine to the shape and size of a clay brick, 215 mm x 102.5 mm x 65 mm, 315 mm x165 mm x 148 mm, 230 mm x 215 mm x 115 mm, 190 mm x 90 mm x 90 mm, etc. bricks shaped and pressed by hand in a sanded wood mould and dried and fired have sandy texture are regular in shape and can be as facing bricks due to the variety of their shapes, colour texture. However, machine-made bricks are hydraulically pressed into steel moulds or extruded as a continuous band of clay, the continuous band of clay; the length and width are cut into bricks by a wire frame. Bricks made or baked this way can be described as wire cuts bricks.

This type of brick can be described as sand-lime bricks. They are manufactured (made) carefully under a controlled mixture of clean sand and hydrated lime mixed together with clean water and moulded in uniform shape and colour. It can be modified or hardened in a stream oven. However, the clay is carefully selected and accurately proportioned to ensure uniform hardness shape, and durability, known for high strength, and fire resistance. They are lightweight and have good insulation properties, making them suitable for high-rise buildings or areas where thermal insulation is important [2].

These types of bricks are made from selected clay that has been carefully prepared by crushing and heavily moulded and carefully burnt so that the finished bricks product can be solid, hard and safely carry much heavier loads than the common types of bricks. These types of bricks are predominately used for walls carrying exceptionally heavy loads for brick piers and generally for engineering works or operations. Engineering bricks are a type of bricks used where strength, low water porosity or acid (flue gas) resistance are needed. Engineering bricks can be used for damp-proof courses. Examples of situations where engineering bricks can be used include underground works manholes, sewers, and retaining walls, constructing urban streets and damp-proof courses.

Engineering bricks are rated as Class A or Class B, with Class A being the strongest and less porous engineering bricks, usually blue due to the high firing temperature whilst class B is more common usually red. Class A engineering bricks have a compressive strength greater than 125 N/mm2 and water absorption less than 4.5%. Class B engineering bricks have a compressive strength greater than 75 N/mm2 and water absorption less than 7% [3].

Soft mud moulded bricks are formed when a clot of clay coated with sand is thrown, by hand or machine, into mould. The bottom of the mould is formed by a stock and a kicker may be placed on the stock to form a frog. This type of brick is not available in Nigeria but is very common in Europe. There are various types in Europe. Those common bricks are cheaper and they are used for any work, but in rare cases, frogged bricks are use except in certain cases they can be selected for a fair face finish. Facing brick is manufactured in varieties such as sand face, hard-pressed and glassed brick.

Clay bricks are not very common in Nigeria; it is not as popular as sandcrete hollow block, as a result, they are not produced in commercial quantities and quality. Clay brick, an earthen-strong, important building material, has been used for centuries. This material has been tried in many different ways, for example sun-dried, fired and so on. The sun-dried brick was first discovered in 800BC while the fired brick has been used circa 4500 BC [4,5].

Clay bricks are man-made materials that are widely used in building, civil engineering work, and landscape design [6]. In the last decades, the importance of historical buildings surfaced due to culture and technology, more ideas and innovations to upgrade clay caused a large increase in studies involving ancient building materials. When sun-dried and burned, clay brick is simple to make, and lighter than stone, easy to mould, and yields a long-lasting, fire-resistant wall. Clay brick is well durable for both internal and external walls and is used for real estate development in the developed world. Sun-drying and burnt techniques which were adopted for producing clay brick; contained natural fibers, such as straw, which were added to the clay mixture as reinforcement. This method processes no carbon emissions and consumes little energy in the production process [7]. However, the small quantities produced or manufactured in Nigeria are manufactured in kilns in some states in Nigeria, they are manufactured in various types and sizes including load-bearing, non-load-bearing and decorative partitions. Clay bricks can be used to replace wood, concrete and other construction materials as it is being used in Scandinavian courtiers (Sweden, Norway, Demark, etc). Moreover, Clay bricks also can be recycled to attain its original quality. Due to its wide–ranging properties, high resistance to atmospheric conditions, low tensile strength, hard high creep resistance, geochemical purity and easy access to its deposit near the Earth Surface, and low mining cost such as its availability in all the 18 Local governments in Ondo state, this makes it suitable and affordable. Commercially produced clay bricks in Nigeria are scarcely found in the construction material market [8]. Reasons are attributed to construction industries and contractor's inability to promote clay bricks as suitable materials for all types of buildings in Nigeria. All commercially produced clay bricks at present in Nigeria are too expensive for both lower and middle class to purchase equally, skill artisans are not available in every state in Nigeria [8]. Comparing the cost of commercially produced sandcrete blocks, with cement-stabilized clay bricks produced locally is economically cheaper and affordable than commercially produced sandcrete blocks because only small quantity of cement is needed for stabilization [9]. The increased strength of clay-cement mix results from the physiochemical reaction between soil and cement, such as the interaction between the substances founded on the soil and the products of the hydration of cement [10].

Classification of bricks

Based upon the physical and mechanical properties, bricks are classified into four types of class, [11].

First class bricks: The type of bricks in this class are thoroughly burnt and are of deep red, cherry or copper colour, the surface should be smooth and rectangular, with parallel, sharp and square corners, and also free from cracks and stone. The water absorption is between 12 – 15% of its dry weight. The crushing strength should not be less than 10 N/mm2 [11].

Second class bricks: In this type of bricks, small cracks and distortion are permitted, turning deep red when burnt. A little higher water absorption of about 16 – 20% of its dry weight is allowed. The crushing strength should not be less than 7.0 N/mm2 [11].

Third class bricks: This class of bricks is under burnt, soft and light-coloured, and they produce a dull sound when struck against each other. Water absorption is about 25% of its dry weight. It is used for building temporary structures [11].

Fourth class bricks: These bricks are over-burnt, badly distorted in size and shape and brittle in nature. The ballast of such bricks is used for foundation and floors in lime concrete and road metal [11].

In the last few years, the resources for construction have not been readily available, house demand has risen due to the increase in population. Owing a shelter in Nigeria has been a major problem for the middle and lower classes of citizens due to the high cost of building construction materials and maintenance. One way to address this challenge is to encourage investors to use locally available materials such as clay bricks mixed with stone dust and cement. The high cost of building bricks is currently being transferred to the investors, indirectly affecting the Nigeria building industry and hence the economy. Thus, the possible benefits of this research in terms of technology, economy and care for the environment are high.

Due to the increasing population and demand for housing/accommodation, mostly relying on conventional materials without the invention of new materials may lead to the depletion of conventional materials, so civil engineers are in the situation to use other materials effectively in construction works without compromising the quality of the materials. However, in recent times, modern building materials that conform to the standards of international regulations, meet the basic needs of safety, economy, good aesthetics and constructability desired for engineered structures and satisfy the contemporary expectations of sustainability and durability have been introduced to the construction industry. The use of clay brick is common in rural areas due to its closeness and does not cost much in building projects or in a low-cost housing project.

The use of low-cost locally produced bricks in Nigeria and their application in the building industry has not gained much popularity except on very few occasions. Hence this research seeks to find a way to incorporate the use of clay/stone dust in the production of bricks for a probable cost reduction; local content application, creation of local employment and development of indigenous technology as a result of its ready availability.

2. RESEARCH METHOD

2.1 Materials

In the course of this research work, the following material samples were used. These include clay, stone dust, cement, and water. The basic characterization of these materials was carried out in accordance with British standards and other internationally accepted engineering standards, in line with the Nigerian Industrial Standard (NIS) as specified by the Standard Organization of Nigeria (SON) for moulding blocks and bricks.

A. **Clay:** The clay materials required for the moulding of bricks was obtained from Akure in Ondo State. A sieve analysis test and some other tests were carried out on the clay sample to ascertain its grading and suitability for brickmaking.
B. **Stone dust:** The stone dust used in this research was purchased from a Quarry Company in Akure and necessary tests were carried out on it.
C. **Cement:** Ordinary Portland Cement of strength class 42.5N was used for this project. The cement was manufactured by Dangote Cement and was purchased in the north gate area of the Federal University of Technology, Akure in 50 kg bags.
D. **Water:** Clean and potable water free of impurities was obtained from the school premises for all activities where it is required. The water satisfies the requirements of bricks mixing water as per British Standards (BS EN, 1997)

2.2 Tools and Equipment

Some of the equipment that was used to carry out the research work are:

i. **Sieves**: A sieve, fine mesh strainer, or sift, is a tool used for separating wanted elements from unwanted material or for controlling the particle size distribution of a sample, using a screen such as a woven mesh or net or perforated sheet material (Ruhlman and Bourdain, 2007). These are of different dimension that helps classify soil samples into size based.

ii. **Wooden formwork**: These will be used as mould for the casting of the clay bricks, as shown in Plate 1.

iii. **Kiln:** A kiln is a thermally insulated chamber, a type of oven, which produces temperatures sufficient to complete some process, such as hardening, drying, or chemical changes. Kilns have been used for millennia to turn objects made from clay into pottery, tiles and bricks. A sample of a kiln is shown in Plate 2.

Plate 1: Wooden mould

Plate 2: Kiln

iv. **A universal testing machine (UTM):** A universal testing machine, also known as a universal tester, (Davis, 2004) materials testing machine or materials test frame, is used to test the tensile strength and compressive strength of materials. Compression strength test on brick to determine the load-carrying capacity of bricks under compression will be carried out using this machine. Plate 3 shows the universal testing machine.

Plate 3: Universal Testing Machine

iv. Others include curing thank, hand trowel, shovel, and measuring scale.

2.3 Methods
The stages of works carried out are outlined as follows:
2.3.1 Procurement of materials
All materials were sourced locally.
2.3.2 Brick manufacturing method
Preparation of brick samples

The process of making bricks, includes mixing, moulding, drying at room temperature, oven drying, and firing. In this study, clay is replaced by stone dust in five different percentage (5%, 10%, 15%, 20%, and 25%) mixed with cement and water. First, the control brick (0%) was prepared by mixing clay soil with cement and water. The other mix were done by replacing the clay soil with stone dust at different percentage of 5%, 10%, 15%, 20%, and 25%. A constant 8kg of cement was added to all the mix serving as a binder.

The mixture was then pressed into moulds with dimensions: 215mm x 102.5mm x 65mm and pressed at 2000psi. Pressing the bricks at high pressure helps in compact by removing the pores present in the clay mixture. After removing the bricks from moulds, they were dried at room temperature for 24 hours to reduce the moisture content of the bricks. The final process of the bricks production involves the firing of the bricks which was carried out at the Industrial Design Department, FUTA.

2.4 Tests Conducted on the Materials
The test that was carried out is as follows:
2.4.1 Determination of particle size distribution

A particle size distribution analysis (PSD) was used to determine and give information about the size and range of particles representative of the acquired clay and stone dust samples. This analysis was performing using sieve analysis technique. The particle size distribution was done in accordance with BS 1377:1990 (Part 2:9) and ASTM C136∕136M-19 Standard test method using set of sieves and shaker. A sieve analysis can be performed on any type of non-organic or organic granular materials including sands, crushed rocks, clay, etc. The result of this test is used to describe the properties of the aggregates and to if it is appropriate to use the soil for various civil engineering purposes. Also, the Atterberg Limit test and the particle density test were performed in accordance with BS 1377-2.

2.4.2 Specific gravity
Specific gravity or relative density is defined by American Standard for Testing and Materials (ASTM) as the ratio of the density of a material to the density of distilled water at a stated temperature. ASTM C 128 is the procedure for obtaining specific gravity. The specific gravity of an aggregate gives valuable information on its quality and properties and it is seen that the higher the specific gravity of an aggregate, the harder and stronger it is.

3.4.3 Bulk Density
Bulk density is defined as the weight per unit volume of material. Bulk density is primarily used for powders or pellets. ASTM D1895B is the procedure for obtaining bulk density. The test can provide a gross measure of particle size and dispersion which can affect material flow consistency and reflect packaging quantity.

2.4.4 Water Absorption
Water absorption test was carried out to determine the amount of water absorbed by a given sample and specified conditions. The initial weight of the bricks in a dry state was measured using weigh balance. Six (6) samples, three (3) fired and three (3) unfired were selected for each replacement percentage, weighted and soaked in a water tank for 24 hours, thereafter it was allowed to drain and reweighed to determine their water absorption rate. It was done in accordance with the ASTM C 140 Standard test method and BS 3921 standard. Samples of soaked bricks are shown in Plate 4.

Plate 4: Bricks soaked in water

2.4.5 Compressive strength test

Compressive strength is the capacity of a material to resist or withstand an applied force under compression. During the course of this work, the compressive strength of both fired and unfired clay bricks with curing age 7, 14, 21 and 28 days was determined by conducting a compressive strength test, testing the ability of the materials to resist failure in the form of cracks and fissure. It was carried out according to ASTM C 129 and BS 3921 standard.

2.4.6 Chemical Oxide Composition

X-ray fluorescence spectrometry (XRF) was used to determine the chemical composition and mineralogical phase of raw minerals. The experiment was carried out using the X-ray fluorescence (XRF) machine at the Engineering Materials Development Institute (EMDI), Ondo Road, Akure.

2.5 Mix Design and Proportion

The mix ratio used was in percentage replacement of clay with stone dust. Cement was added at a constant of 5%, while the stone dust was added in different numbers as shown in Table 1. The weight of water was constant. A final sum of 288 bricks was moulded for this study.

Table 1: Mix proportion of the experimental samples

% Replacement	Cement(kg)	Clay(kg)	Stone dust(kg)	Water – Cement Ratio	No. of bricks
0	8	160	--	0.5	48
5	8	152	8	0.5	48
10	8	144	16	0.5	48
15	8	136	24	0.5	48
20	8	128	32	0.5	48
25	8	120	40	0.5	48

3. RESULTS AND DISCUSSIONS

3.1 Result

The results presented in this chapter are obtained from the tests carried out on cement, clay, and stone dust. Physical and mechanical properties such as compressive strength and water absorption of bricks were also evaluated.

3.2.1 Cement

Ordinary Portland cement 42.5N grade (Dangote cement) was used as a binder for this study. Consistency, soundness, and fineness tests were carried out on the cement binder and the results of the test are presented in Table 2.

Table 2: Consistency test

S/N	Properties/Parameters	Results
1	Consistency time (minutes)	11
2	Initial setting time (minutes)	46
3	Final setting time (minutes)	551
4	Soundness test (%)	4.89
5	Fineness test (%)	1.90

3.2.2 Characterization of raw materials

(i) Particle size distribution

The material samples were subjected to sieve analysis test and the results for clay soil and stone dust are represented graphically in Figure 1.

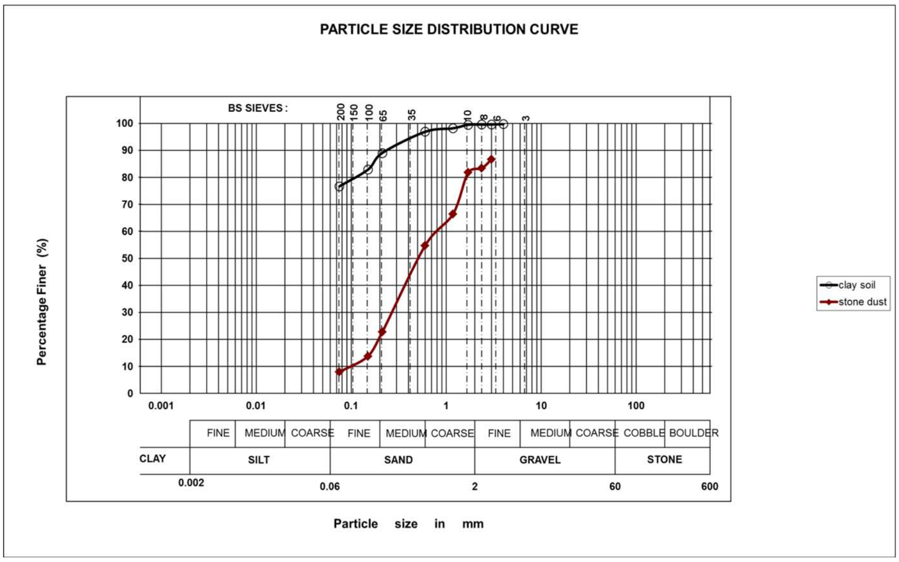

Figure 1: Particle size distribution curve for both clay soil and stone dust

ii. Geotechnical properties of clay soil

Table 5 shows the geotechnical properties of the raw material. This was carried out in order to examine the behavior of the clay soil in terms of liquid limit and plastic limit, an Atterberg limit test were carried out. The result gave a liquid limit of 24.57%, plastic limit of 5.57%, and plasticity index of 19.0%. Based on AASHTO system of classification, the clay soil used is classified under A-7-6 clayey soil. The results of the Atterberg limit test of clay soil are in compliance with the standard requirements established by Mueller *et al.* (2003).

(iii) Specific gravity, Moisture content and bulk density of raw materials

Table 3 shows the specific gravity and bulk density of both clay soil and stone dust. The results show that the specific gravity of clay soil is 2.66, while the specific gravity of stone dust is 2.70. Generally, the specific gravity of inorganic clays ranges from 2.70 to 2.80 normally varies between 2.6 and 2.9 as specified by ACI EI 201 (2001). The bulk density of clay soil is 1630.0kg/m^3, while the bulk density of stone dust is 1610.0 kg/m^3.

Table 3. Classification characteristic of clay soil

Properties	Clay soil
Liquid limit (%)	24.57
Plastic limit (%)	5.57
Plasticity index (%)	19.00
Degree of plasticity	Low plasticity
Type of soil	Silt-clay

Table 4. Physical properties of material.

	Clay	**Stone dust**
Specific gravity	2.66	2.70
Bulk density (kg/m^3)	1630.0	1610.0
Moisture content (%)	16.30	2.56

(iv) Chemical composition of Clay soil and Stone dust

The chemical composition of clay soil and stone dust used for this study was evaluated through an X-ray fluorescent (XRF) test. The results of the test are presented in Table 5. According to the X-ray fluorescent (XRF) test results obtained, the clay soil contained 34.20% iron oxide (Fe2O3), 23.59% silicon dioxide (SiO2), 10.13% aluminum oxide (Al2O3), 9.91% antimony pentoxide (Sb2O5), and 9.64% tin (IV) oxide (SnO_2). Fe_2O_3 is abundant in the clay soil sample, thus contributes to strong and hardness of bricks also gives red colour to burnt bricks. The high presence of SiO_2 in the clay sample gives it excellent resistance to thermal shock and can withstand high temperature. The presence of low Al_2O_3 in the clay sample helps to impact plasticity to the clay so that it can be moulded and also prevent cracks in bricks on drying. The presence of Sb_2O_5 in the sample is good because of its fire-retardant properties. The test analysis results found that there are other oxides present in the clay soil sample as shown in Table 9.

Stone dust is a common material used in various construction applications, such as the manufacturing of bricks. The composition of stone dust plays a crucial role in determining the properties and characteristics of the final product. In this analysis, the X-ray fluorescent (XRF) shows that the stone dust containing 30.22% iron oxide (Fe_2O_3), 28.46% silicon dioxide(SiO_2) , 11.29% tin (IV) oxide (SnO_2), 10.68% antimony pentoxide (Sb_2O_5), and 8.08% aluminum oxide (Al_2O_3) , which is mixed with clay to make bricks. Fe_2O_3 imparts a reddish color to the material. This component also contributes to the durability and strength of the bricks. SiO_2 serves as a binding agent, helping to hold the particles together and enhancing the cohesion of the mixture. SnO_2 plays a role in the firing process of the bricks, acting as a flux that helps lower the melting point of the materials and promoting better sintering. Sb_2O_5 contributes to the overall chemical stability of the bricks, reducing the risk of deterioration over time. Al_2O_3 provides additional strength and resistance to the bricks, making them more suitable for withstanding external forces and environmental conditions. When mixed with clay, these components combine to form a robust and durable material that is ideal for brick manufacturing.

Furthermore, there are other oxides that contribute to the chemical composition of the stone dust.

Table 5. The Chemical Composition of the materials.

S/N	Elements	Oxide content	Stone Dust (%)	Clay (%)
1	Aluminium	Al_2O_3	8.08	10.13
2	Silicon	SiO_2	28.46	23.59
3	Phosphorus	P_2O_5	0.55	0.37
4	Sulfur	SO_3	0.47	0.51
5	Potassium	K_2O	4.81	2.19
6	Calcium	CaO	1.50	0.25
7	Titanium	TiO_2	0.68	6.01
8	Vanadium	V_2O_5	0.06	0.08
9	Chromium	Cr2O3	0.00	0.01
10	Manganese	MnO	0.06	0.11
11	Cobalt	CoO	0.23	0.57
12	Iron	Fe_2O_3	30.22	34.20
13	Nickel	NiO	0.45	0.40
14	Copper	CuO	0.31	0.23
15	Zinc	ZnO	0.69	0.56
16	Lead	PbO	0.03	0.10
17	Tungsten	WO_3	0.51	0.45
18	Gold	Au2O	0.00	0.03
19	Silver	Ag_2O	0.02	0.06
20	Rubidium	Rb_2O	0.02	0.02
21	Niobium	Nb_2O_5	0.00	0.08
22	Molybdenum	MoO_3	0.02	0.50
23	Tin	SnO2	11.29	9.64
24	Antimony	Sb_2O_5	10.68	9.91

3.3 Compressive Strength

Figure 2 shows the compressive strength test results obtained from the brick samples after crushing for 7, 14, 21, and 28 days at different replacements. For unburnt bricks, it shows that the strength of the bricks decreased with an increase in the percentage of stone dust used as a replacement.

Figure 3 shows the compressive strength test results obtained for burnt bricks which indicates rise in the value of the result as there is an increase in the percentage of the stone dust up to 15%, and thereafter continues to decrease with further increase in the percentage of the stone dust.

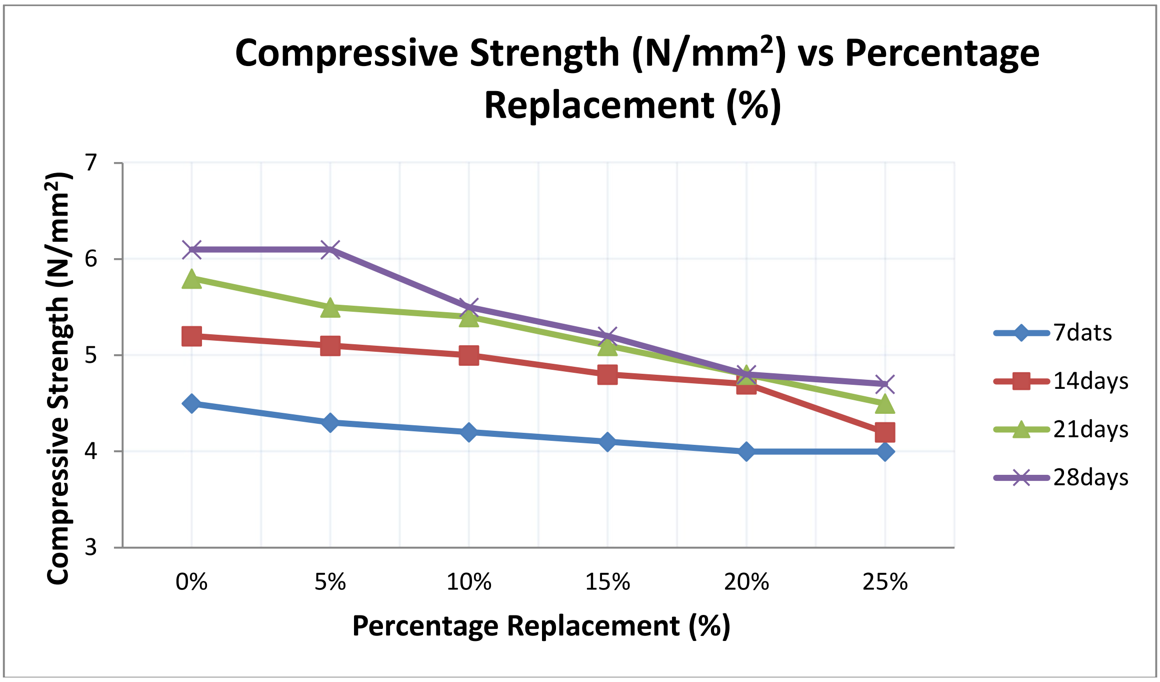

Figure 2: Average compressive strength results at 7, 14, 21, and 28days for unburnt bricks

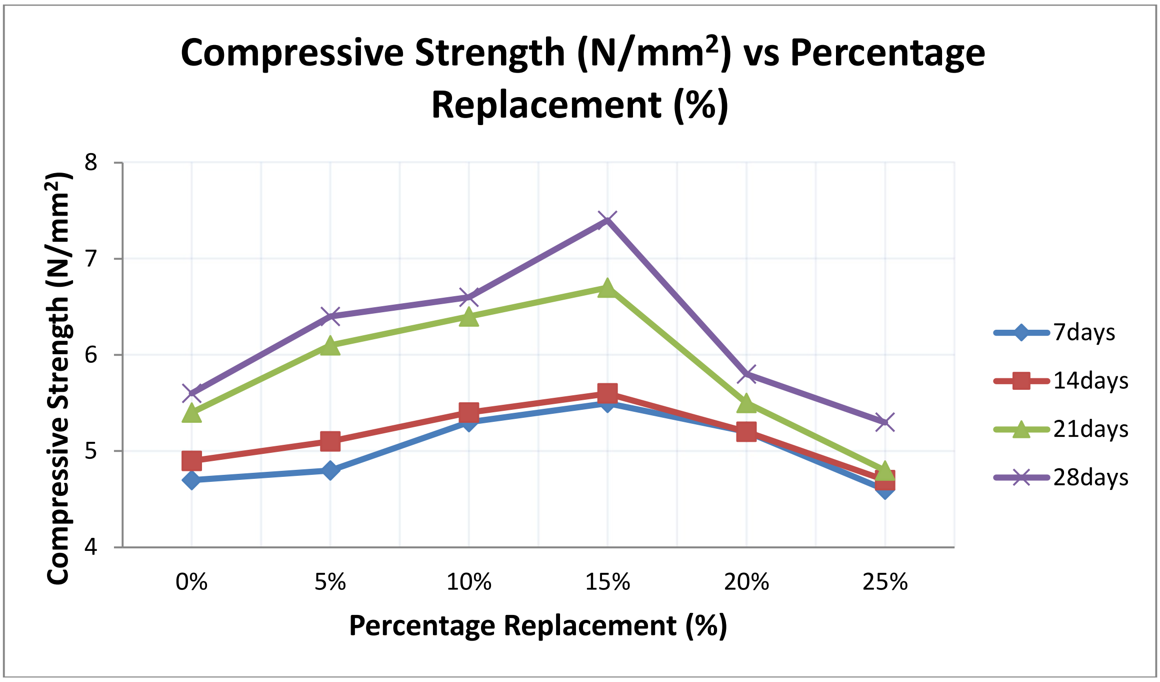

Figure 3: Average compressive strength results at 7, 14, 21, and 28days for burnt bricks

3.4 Water Absorption

From the results of the percentage water absorption obtained as shown in Figures 4 and 5 for burnt bricks for unburnt bricks respectively, it was observed that the rate at which the burnt bricks absorbed water is higher than that of unburnt bricks. The control (0%) of the burnt bricks without stone dust has the lowest percentage of water absorption while the rest has a value of 16% and 20%. The value of the results for the unburnt bricks with the control (0%) having the lowest value of 3.33% and the replacements with a value from 6.90% to 7.69%

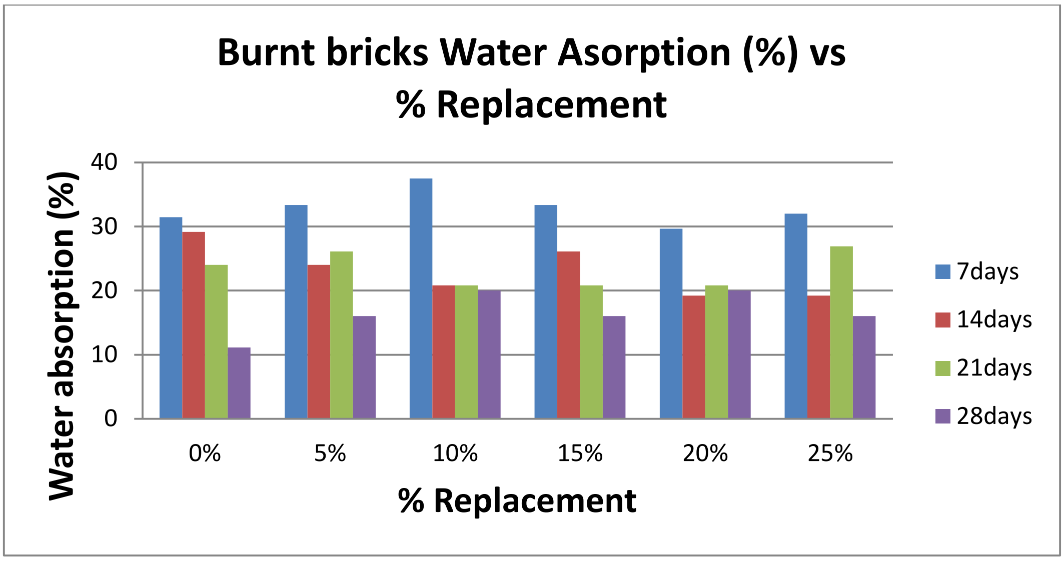

Figure 4: Average percentage of water absorption at 7, 14, 21, and 28days for burnt bricks

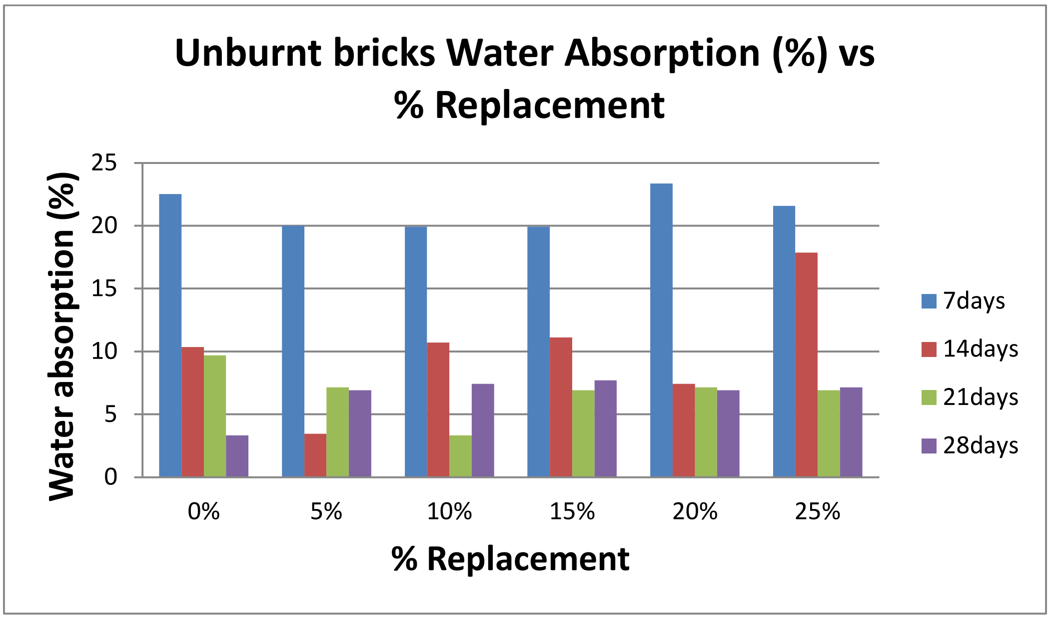

Figure 5: Average percentage water absorption at 7, 14, 21, and 28days for burnt bricks

3. 5 Clay bricks Advantage

Clay bricks are a popular building material and offer several advantages in terms of the following concepts; cost, ease of use, reliability, sustainability and availability of raw materials. (i) Cost-effectiveness: These bricks offer a cost-effective solution for construction projects due to their affordability compared to other building materials, making them a preferred choice for many builders and constructors.

(ii) Ease of use: Clay bricks are highly valued for their ease of use. Their uniform shape and size make them easy to handle and install, reducing construction time and labor costs. Additionally, clay bricks are versatile and can be used in various types of construction projects, adding to their ease of use and practicality.

(iii) Reliability: Clay bricks are known for their durability and strength. They have excellent load-bearing capacity, making them a reliable choice for constructing buildings and structures that need to withstand heavy loads and adverse weather conditions. This reliability ensures that structures built with clay bricks have a longer lifespan and require minimal maintenance over time.

(iv) Sustainability: Clay is a natural material that is abundantly available; making clay bricks an environmentally friendly choice for construction. Additionally, clay bricks have excellent thermal insulation properties, contributing to energy efficiency in buildings and reducing the overall carbon footprint of the construction project.

(v) The availability of raw materials for clay bricks is significant. Clay is found in abundance in nature, making it a readily available and renewable resource for manufacturing clay bricks. This availability ensures a consistent supply of raw materials for producing clay bricks, making them a reliable choice for construction projects of all scales.

Calculation:

Cost of 1 tonne (1000kg) of stone dust/clay	= ₦6500
Cost of 1 bag (50kg) of cement	= ₦8000
Cost of 1kg 0f stone dust/clay	= ₦6500/1000 =₦ 6.50
Cost of 1kg of cement	= ₦8000/50 = ₦160.00
160kg of clay/stone dust + 8kg of cement to produce 48 bricks	
160kg of clay/stone dust	= 160 x 6.50 = ₦1040
8kg of cement	= 8 x 160 = ₦1280
₦2320 produced 48 bricks	
Cost of producing 1 unit of brick	= 2320/48 = ₦48.33
Labour cost (35%)	= ₦16.92
Cost of 1 unit of brick	= ₦65.25

Cost per square meter of brick

Area of brick = 0.225m x 0.1125m = 0.0253125	
Number of brick in one square meter = 1/0.0253125	= 39.51
Approximately	= 40 bricks.

4. CONCLUSION

This research has assessed the strength of engineering bricks produced, using clay soil from Akure, stone dust, and ordinary Portland cement. From the test results obtained from the analysis, it was observed that stone dust can be used to augment in the partial replacement of clay in brick production with little amount of cement as a stabilizer to increase the strength of the bricks. Cement was used here at 5% in order to minimize cost. The experimental results show that stone dust can be effectively used at a certain percentage replacement. Stone dust has much effect in the compressive strength of burnt bricks than that of unburnt bricks due to the chemical oxide composition reaction. From the results obtained, the following conclusion can be drawn;

a. All the aggregates (clay soil and stone dust) used in the experiment met the requirements specified in various BS codes. Also, the cement used shows a good property that is worthy of acceptance.
b. An increase in the percentage of stone dust leads to a decrease in the compressive strength of unburnt bricks but in burnt bricks, it indicates that increasing the proportion of stone dust in the clay brick mixture improves the compressive strength, with the highest strength observed at 15% stone dust and further addition make it reduced.
c. During the water absorption test it was discovered that both burnt and unburnt bricks without the addition of stone dust has the lowest percentage water absorption.
d. It was observed that stone dust can be a substituent in the production of clay bricks.
e. The bricks produced in this study are suitable for construction applications: load-bearing, non-load bearing partition and load-bearing internal walls.
f. The cost of producing clay bricks is cheap.
g. The highest compressive strength obtained in this study is not up to that of engineering bricks of Class A 70 N/mm^2 and Class B 50 N/mm^2, but the strength is of normal bricks 5 N/mm^2 according to BS 3921 standard.

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