COMPARATIVE EFFECTS OF THE CHARACTERISTIC PROPERTIES OF COMPRESSED LATERITE EARTH BRICK STABILIZED WITH PALM LEAF ASH AND PALM KERNEL FIBRE

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Abstract
This study is designed to compare the effects of the characteristics properties of compressed laterite earth brick stabilized with palm leaf ash (PLA) and palm kernel fiber (PKF). The study was carried out in Building Technology Department, Federal Polytechnic Bida, Niger State. Bricks of 222x110x70 were produced using manual pressed machine which 12 bricks each were stabilized with palm kernel fiber for 1%, 2%, and 3%. Also 12 bricks each were stabilized with palm leaf ash for each percent 5%, 10% and 15%. The materials used are Palm Kernel Fiber, Palm Leaf Ash laterite soil, and water. The tests carried out are specific gravity and compressive strength test. The findings showed that the specific gravity of the laterite ranging from 2.78 to 2.75 which is within the specification of Nigerian Building And Road Research Institute NBRRI of 2.7 to 3.0. The 28 days compressive strength of compressed laterite brick stabilized with PKF recorded average strength of 2.04 Nmm^2 at 1%, 2.07 Nmm^2 at 2%, and 2.26 Nmm^2 at 3%. They all conformed to NBRRI 2006 specification of 1.65Nmm^2, While the 28 day compressive strength of compressed laterite bricks stabilized with PLA recorded average strength of 1.72Nmm^2 at 5%, 1.79Nmm^2 at 10% and 1.81Nmm^2 at 15%. All result are in conformity with the NBRRI 2006 specification of 1.65 Nmm^2. The bricks stabilized with PKF produced higher compressive strength compared with the bricks stabilized with PLA. Therefore, compressed laterite earth bricks stabilized with PKF and PLA can be used for walling materials in order to reduce the cost of building.

Keywords: Compressed Laterite Bricks, Palm Leaf Ash, Palm Kernel Fiber, Specific Gravity and Compressive Strength.

Introduction

Cheap building materials are necessary for the development of low cost housing in Nigerian. In particular, non-fired laterite bricks are attractive building material because they are inexpensive to manufacture compared to conventional block and burnt brick which are commonly used for building houses. Housing can be described as an essential component of human settlement that comparably ranks to the provision of food and clothing in the hierarchy of the basic primary elements required for human existence. At its most elementary level, it addresses the basic human needs providing shelter, offering protection against excessive cold, heat, rain, high winds and any other form of inclement weather, and also protection against unwanted aggression (Emmanuel, 2019). In quest to acquire this essential component of human settlement, there is a search for different building materials to be used.

Building materials have been playing an important role in the construction industry, building materials are those materials put together in erecting or constructing structures, no field of engineering is conceivable without their use Akanni *et al* (2014). The materials used in building construction include Cement, Sand, Water, Iron rod and some others. The cost of building materials poses a significant threat to both the construction industry and people aspiring to own houses (Anosike, 2009).Idoro and Jolaiya (2010) affirmed that many projects were not completed on time due to the cost of materials, which have been on the increase, hence need for alternative building material.

The alternative material that seems to be used for constructing building wall in Nigeria is compressed earth brick stabilized with agricultural wastes like rice husk, palm kernel fibre and palm leaf ash, this is due to high cost of other building material in order to minimized housing problem in Nigeria. Palm tree is a kind of tree that grows in tropical regions and has a straight, tall trunk and many large leaves at the top of trunk. Palm kernel fibre is a waste gotten from the extraction of palm oil from the kernel disposed after the content is used. These wastes often cause great environmental degradation that usually results in pollutions, blocking of water channels and in most cases to outbreak of disease. Palm kernel fibre is a waste gotten from palm fruits after the oil is been extracted and it has the property of increasing hardness value of brick. Walid *et al.* (2019) reported that the waste material, palm ash has been introduced as a competent binder in enhancing mortar and concrete properties. Palm ash is found to have great potential and it may be effectively utilized as construction material in reducing the CO_2 emission into the atmosphere and minimizing the cost of building materials such as concrete blocks and bricks that are used for construction without compromising the service life of the structures. The specific gravity is the ratio of the density of a substance to the density of a reference substance; equivalently, it is the ratio of the mass of a substance to the mass of a reference substance for the same given volume. Specific gravity test is done to measure the strength or quality of the material (Nissa, 2015). Specific gravity of the soil is one of the engineering properties, which plays an important role in analysis of geotechnical problems even before the additives are added. Palm kernel fibre as an additive is a waste gotten from palm fruits after the oil is been extracted and it has the property of increasing hardness value of brick.

Compressed Laterite Bricks (CLB) are masonry elements, which are small in size and have regular shape with verified characteristics obtained by the static or dynamic compression of earth in a humid state followed by immediate remolding. Compressed laterite bricks generally have a rectangular format and are full or perforated with vertical and/or horizontal indentations. (Oyelami & Rooy, 2016).It is obvious that there are abundance of laterite in many parts of Nigeria and also availability of agricultural waste such as palm kernel fiber (PKF) and palm leaf ash (PLA) that can be used to produced material for building walls.

Statement of the Research Problem

Building infrastructure is one of the basic need of man after food. The construction of buildings depends greatly on conventional materials such as cement, gravels, sand and others for the manufacturing of walling unit (brick and block). Cement undeniably is one of the most essential and expensive commodities in the construction sector. This have certainly made decent accommodation beyond the reach of many people (Kareem, Idowu &Sode, 2014). More so, there are a lot of literatures on the use of natural and agricultural materials that can be used for the construction of low cost housing. Many scholars Nwofor (2012) and Abdulkadir (2016) in their study show the possibility of using agricultural and industrial waste for partial replacement of cement in building construction, which may possibly be an option of reducing high cost of building a house by low income earners, but there is use of cement which is an expensive conventional building material.

Therefore, the researcher compared the effect of the characteristic properties of compressed laterite earth brick stabilized with palm kernel fibres and palm leaf ash with NBRRI standard in order to explore their suitability for building construction to make housing accessible for low income earners.

Purpose of the Study

The main purpose of the study is to compare the effect of PKF and PLA on characteristic properties of compressed laterite earth brick. Specifically, the study:

1. Determined the specific gravity of laterite sample for the production of compressive laterite brick stabilized with PKF and PLA
2. Compared the Compressive strength effect of compressed laterite Brick stabilized with PKR and PLA

Research Questions

The following research questions guided the study:

1. What is the specific gravity of the laterite sample for production of compressive laterite brick stabilized with PKF and PLA?
2. What is the effect of the compressive strength of compressed laterite brick stabilized with PKF and PLA?

Materials and Methods

The study adopted experimental Research design. According to Patrick, Kamseu&Arlin (2015) experimental Research design is the blue print of procedure which enables the researcher to test hypothesis by reaching valid conclusions about relationship between dependent and independent variables. Specific gravity test and compressive strength test were carried out in Building Department laboratory of Federal Polytechnic Bida, Niger state of Nigeria.

The materials used for the production of compressed laterite earth bricks (CLEB's) were obtained locally, manually operated compression machine of222mm×100mm×70mm was used. laterite was used for the production of CLEB's. The laterite samples used were air-dried for seven days in a cool dry place. Air drying was done to enhance grinding and sieving of the laterite. After drying, grinding was carried out using a punner and hammer to break the lumps present in the soil. Sieving was then done to remove oversized materials from the laterite sample using a wire mesh screen with aperture of about 5.0mm diameter, Fine materials passing through the sieve were collected for use while those retained were poured away. Palm leaf ash and palm kernel fiber were used as additives for the production of compressed laterite earth bricks.

The tests carried out:

1. Specific gravity test
2. Compressive strength test

Procedure for specific gravity test of laterite sample

The following are the procedures for the specific gravity test of the laterite sample:

1. The laterite sample was dried thoroughly and free of moist
2. Empty bottle was weighed, the weight was coded as W1.
3. The empty bottle was filled with 1/3 of laterite, weighed and coded as W2.
4. Density bottle was filled with 1/3 of laterite with full water, weighed and coded as W3.
5. Density bottle was filled with clean water, weighed and coded as W4.

The formula for specific gravity of any construction materials used for building construction can be express as ; $\frac{W2 - W1}{(W4 - W1) - (W3 - W2)}$ = specific gravity of that materials.

Where;
W1= weight of empty bottle.
W2= weight of bottle with laterite (sample).
W3= weight of bottle, laterite sample and water.
W4= weight of bottle and clean water.

Procedures for Mixing Laterite, Palm Kernel Fibre and Palm Leaf Ash

1. Laterite of 101.64g and palm kernel fibre of 1.02g for 1% stabilization, 2.04g, for 2% stabilization, 3.06g for 3% stabilization were measured
2. The measured laterite and PKF was mixed together thoroughly using water.
3. Laterite of 101.64g and palm leaf ash of 5.08g for 5% stabilization, 10.16g, for 10% stabilization, 15.25g for 15% stabilization was measured
4. The measured laterite and PLA were mixed together thoroughly using water on impermeable surface.

Procedures for molding compressed stabilized laterite brick

1. The mold of manual press machine was cleaned and oil to reduce friction and easy remover.
2. The mold was filled with the laterite and compacted using taping rod.
3. The mold was press down manually for maximum compression
4. The mold was press up manually to enable easy removal of the brick

Procedures for curing compressed stabilized laterite brick

1. Bricks were kept close to each other to avoid rapid drying.
2. Nylon was used to cover the bricks.

The curing days of the bricks is from 7 days to 28 day.

Procedures for testing compressive strength of compressed stabilized laterite brick

The compressive strength test machine was used for this test. A total of 72 compressed stabilized laterite Brick were casted, 12 bricks for each percent and 3 bricks were crushed for each percent at 7, 14, 21 and 28 days of curing. The bearing surface of the compressive strength testing machine was cleaned very well, a brick sample was placed appropriately on the machine to crushed the brick sample gradually as a careful observation is being made. As soon as the brick is crushed the machine was stopped and the reading was taken, the crushed sample was removed. The procedure was repeated until all the samples were crushed.

$$\text{Compressive strength} = \frac{\text{load to failure } (KN/m^2)}{\text{area of bricks}}$$

Result

What is the specific gravity of the laterite sample used for the production of Compressed Stabilized Laterite Earth Brick?

The results analyzed for research question two are presented in Table 1.

Table 1: The Results of the Specific Gravity of The Laterite Sample used for the Production of Compressed Stabilized Laterite Earth Brick.

No. of trials	1	2
Mass of bottle + plate W1	185	182
Mass of bottle + soil + plate W2	385	383
Mass of bottle + soil + plate + water W3	887	886
Mass of bottle + plate + water W4	759	758
SG= $\frac{W_2-W_1}{(W_4-W_1)-(W_3-W_2)}$	2.78	2.75

The Table1 shows the specific gravity of the laterite sample.

The result of the specific gravity test of laterite soil samples are 2.78 and 2.75 which is within the range of standard specification of NIS and therefor considered good in quality and suitable for the production of compressed laterite Earth bricks. NIS Specification: The specific gravity of laterite soil ranges between 2.75 to 3.0.

Research Question Two

What is the effect of compressive strength of Compressed Stabilized Laterite Earth Brick Stabilized with PKF and PLA?

Table 2. The results of compressive strength test of Compressed Stabilized Laterite Earth Brick Stabilized with Palm Kernel Fiber. Laterite Earth Brick Stabilized with Palm Kernel Fibre#

Percentage (%)	Days	No. Bricks	Area	Load	Average	CS
	7	1	24420	76100		
	7	2	24420	65100		
	7	3	24420	70790	70663	2.89
	14	4	24420	64460		
	14	5	24420	53470		
	14	6	24420	58960	58963	2.41
1	21	7	24420	58720		
	21	8	24420	42330		
	21	9	24420	53970	51673	2.11
	28	10	24420	44030		

	28	11	24420	54700		
	28	12	24420	49360	49363	2.02
	7	13	24420	97800		
	7	14	24420	55840		
	7	15	24420	76820	76820	3.15
	14	16	24420	77450		
	14	17	24420	61000		
	14	18	24420	76450	71633	2.93
2	21	19	24420	69880		
	21	20	24420	72480		
	21	21	24420	59370	67243	2.75
	28	22	24420	53210		
	28	23	24420	47780		
	28	24	24420	50490	50493	2.07
	7	25	24420	67340		
	7	26	24420	97990		
	7	27	24420	88810	84713	3.47
	14	28	24420	80730		
	14	29	24420	79480		
	14	30	24420	81330	80513	3.3
3	21	31	24420	60510		
	21	32	24420	75160		
	21	33	24420	67990	67887	2.8
	28	34	24420	49570		
	28	35	24420	60920		
	28	36	24420	55380	55290	2.26

Key: CS = Compressive Strength

The result in Table 2. of laboratory test revealed that compressive strength of bricks stabilized with Palm Kernel fiber (PKF) at 1% for 7 days, 14 days 21 days and 28 days to be 2.89N/mm^2, 2.43N/mm^2, 2.04Nmm^2, and 2.02N/mm^2. The result further revealed that the bricks stabilized PKF at 2% have 3.05N/mm^2 at 7 days, 2.91N/mm^2 14 days, 2.75N/mm^2 21 days, and 2.07N/mm^2 28days. And the bricks stabilized at 3% have compressive strength of 3.47Nmm^2 at 7 days, 3.29Nmm^2 at 14 days, 2.77Nmm^2 at 21 days and 2.26Nmm^2 at 28 days.

These results of compressive strength showed that all the bricks conformed with the NBRRI specification.

Table 3. The results of compressive strength test of Compressed Stabilized Laterite Earth Brick Stabilized with Palm Leaf Ash.

Percentage (%)	Days	No. Bricks	Area	Load	Average	CS
	7	1	24420	39160		
	7	2	24420	38570		
	7	3	24420	30890	36207	1.48
	14	4	24420	40100		
	14	5	24420	38290		
5	14	6	24420	40200	39017	1.6

	21	7	24420	39600		
	21	8	24420	38290		
	21	9	24420	45030	40973	1.68
	28	10	24420	43610		
	28	11	24420	34040		
	28	12	24420	48280	41977	1.72
10	7	13	24420	36260		
	7	14	24420	37890		
	7	15	24420	48000	40717	1.67
	14	16	24420	47500		
	14	17	24420	48730		
	14	18	24420	38170	424667	1.73
10	21	19	24420	30210		
	21	20	24420	41280		
	21	21	24420	57320	42937	1.76
	28	22	24420	41160		
	28	23	24420	38310		
	28	24	24420	51720	43730	1.79
	7	25	24420	47600		
	7	26	24420	40720		
	7	27	24420	38780	42367	1.73
	14	28	24420	46310		
	14	29	24420	38530		
15	14	30	24420	42970	42603	1.74
	21	31	24420	45920		
	21	32	24420	43390		
	21	33	24420	42450	43920	1.8
	28	34	24420	40630		
	28	35	24420	46040		
	28	36	24420	46280	44317	1.81

Key: CS = Compressive Strength

The result of the laboratory experiment in Table 3 revealed the compressive strength of the brick stabilized with Palm Leaf Ash at 5.0% stabilization to be 1.48 Nmm^2 at 7 days, 1.60Nmm^2 at 14 days, 1.68Nmm^2 at 21 days 1.72Nmm^2 at 28 days. The compressive strength of the bricks stabilized with palm leaf ash (PLA) at 10% have 1.67Nmm^2 at 7 days, 1.73Nmm^2 at 14 days, 1.76Nmm^2 at 21 days, and 1.79Nmm^2 at 28 days. The result further revealed the compressive strength of the bricks at 15% stabilization to be 1.73Nmm^2 at 7 days, 1.74Nmm^2 at 14 days, 1.80Nmm^2 and 1.81Nmm^2 at 28 days. These are in conformity with NBRRI Specification for compressive strength of compressed laterite brick of 1.65 Nmm^2.

Findings of Study

1. The specific gravity of laterite used for the experiment has good quality because it falls within the specification of NBRRI of 2.75 to 3.0.
2. Bricks stabilized with palm kernel fiber has compressive strength of 2.04 Nmm^2 at 1%, 2.07 Nmm^2 at 2% and 2.26 Nmm^2 at 3%.
3. The bricks stabilized with palm leaf ash has compressive strength of 1.62 Nmm^2 at 5%, 1.74 Nmm^2 at 10%, and 1.77 Nmm^2 at 15%. Thus the bricks stabilized with PKF produced higher compressive strength.

Discussion of the Findings

The findings of research question one showed that the specific gravity of laterite used for the experiment is 2.78 and 2.75 which falls within the specification of NBRRI of 2.75 to 3.0. this indicate good quality of the laterite. This is in line with Otunyoand Chukuigwe (2018), whose summary of the data obtained from the specific gravity test carried out produced specific gravity of the tested samples between 2.64 and 2.75.

The findings of research question two showed that the effect of compressive strength of compressed laterite brick stabilized with palm kernel fiberis 2.04 Nmm^2, 2.07 Nmm^2, and 2.26 Nmm^2 at 28 days curing. It was observed that the compressive strength of the compressed laterite brick stabilized with palm kernel fiber was reducing as the curing days increases but the compressive strength increases as the percentage of PKF was increased. The results are in conformity with NBRRI standard of 1.65, this indicate that fiber possesses good quality that can improve the compressive strength of compressed laterite brick. In simple comparison in this study, the bricks stabilized with palm leaf ash as shown in table 3 have compressive strength of 1.72 Nmm^2, 1.79 Nmm^2, and 1.81 Nmm^2 it is observed that all stabilized with palm leaf ash at 28 days of curing that falls within the specification of NBRRI of 1.65. Therefore, palm leaf ash can be used as stabilizer at 5.0%, 10% and 15% to improve the compressive strength of compressed laterite brick.

This is in agreement with Raheem and Adeyeye (2012) whose minimum 28 days curing produced compressive strength for 5% cement stabilised blocks of more than 1.60 N/mm^2, as recommended in the National Building Code (2006), was not satisfied by all the blocks. It is also in line with Otunyochukuigwe (2018) who investigated the impact of palm bunch ash (PBA) on the stabilization of poor lateritic soil and find out that theat values of the UCS increased as the PBA content in the lateritic soil was increased. These result showed that the bricks stabilized with palm kernel fiber has better compressive strength than the bricks stabilized with palm leaf ash.

Conclusion

Based on the study it was concluded that the specific gravity of the laterite used for the production of compressed laterite brick is within the standard range of 2.75 to 3.0 Therefore, the laterite considered to be of good quality for production of compressed laterite brick. The compressive strength of compressed laterite bricks stabilized with PKF at 1.0%, 2.0% and 3.0% produced high compressive strength compared to NBRRI specification of 1.65Nmm^2. This makes compressed laterite brick stabilized with (PKF) qualitative, accessible and affordable building material. The compressive strength of compressed laterite bricks stabilized with PLA at 5.0%, 10% and 15% are all in conformity NBRRI specification of 1.65Nmm^2. Thus 5.0%, 10% and 15% stabilization can be used for the production of laterite brick stabilization.

Recommendations

Based on the findings and conclusion of the study the following recommendations were made:

1. Building professionals should sell this ideas of using the compressed laterite bricks stabilised with palm kernel fibre at 1% and 2% and 3% to their client especially the low income earners as it is environmental friendly and cheap since their compressive strength is within the standard specification.
2. The government should make compressed machine available and affordable for the low income earners.
3. Awareness campaign through workshops and social media on the use of compressed laterite bricks stabilised with palm kernel fibre at 1.0%, 2.0%, 3.0% while 5.0% and 10% for palm leaf ash stabilization should be made by stake holders since their compressive strength is within the standard specification.
4. Building construction industry should focus on the importance of the use of natural alternative building materials such as compressed laterite bricks stabilized with palm kernel fibre and palm leaf ash and the conformity with the specifications of NBRRI.

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