International Journal of Research in Civil Engineering and Technology

E-ISSN: 2707-8272
P-ISSN: 2707-8264
IJRCET 2023; 4(1): 44-48
Received: 02-01-2023
Accepted: 05-02-2023

Dr. Igwe
Department of Industrial and Technology Education, Federal University of Technology, Minna, Niger State, Nigeria

Christopher Obeta
Department of Industrial and Technology Education, Federal University of Technology, Minna, Niger State, Nigeria

Jude K
Department of Industrial and Technology Education, Federal University of Technology, Minna, Niger State, Nigeria

Bldr Chinaza
Department of Industrial and Technology Education, Federal University of Technology, Minna, Niger State, Nigeria

Dr. Agunsi
Department of Industrial and Technology Education, Federal University of Technology, Minna, Niger State, Nigeria

Rapheal
Department of Industrial and Technology Education, Federal University of Technology, Minna, Niger State, Nigeria

Bldr. John Okwe Alaezi
Department of Industrial and Technology Education, Federal University of Technology, Minna, Niger State, Nigeria

Corresponding Author:
Dr. Igwe
Department of Industrial and Technology Education, Federal University of Technology, Minna, Niger State, Nigeria

Effects of palm leaf ash and palm kernel fibre on properties of compressed laterite earth brick

Dr. Igwe, Christopher Obeta, Jude K, Bldr Chinaza, Dr. Agunsi, Rapheal and Bldr. John Okwe Alaezi

Abstract

This study is designed to compare the effects of the properties of compressed laterite earth brick (CLEB) stabilized with palm leaf ash (PKA) and palm kernel fiber (KPF). The study was carried out in Building Technology Department, Federal Polytechnic Bida, Niger State. Bricks of 222✕110✕70 were produced using manual pressed machine which 9 bricks each were stabilized with palm kernel fiber for 1%, 2%, and 3%. Also 9 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 were abrasion resistance test and water penetration test. These findings showed that the water penetration rate for the CLEB bricks stabilized with PKF recorded average penetration rate of 10.18 at 1%, 11.52 at 2% and 12.19 at 3%. Only 3% produce higher penetration rate while CLEB stabilized with PLA recorded average water penetration rate of 11.58 at 5%, 10.63 at 10%, and 11.27 at 15%. All were in conformity with NBRRI specification of 12.5%. The abrasion resistance of the 28day CLEB stabilized with PKF recorded average abrasion of 1.40 at 1%, 1.28 at 2% and 3.68 at 3%. All result were conformity with the NBBRI specification of 6.9. While the abrasion resistance of the 28day CLEB stabilized with PLA recorded average abrasion of 2.39 at 5%, 2.22 at 10% and 2.32 at 15% which is are in conformity with the NBBRI specification of 6.9. based on the findings of the study it was concluded that the CLEB stabilized with palm kernel fiber at 1% and 2% are in conformity with NBRRI specification of compressive strength, water absorption rate and abrasion resistance. While compressed laterite bricks stabilized with palm leaf ash should be improve to conform to NBRRI specification.

Keywords: CLEB bricks, palm leaf, absorption rate

Introduction

Affordable and accessible building materials are necessary for the construction 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) [1]. 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) [2]. The materials 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 While Idoro and Jolaiya (2010) [3] affirmed that many projects were not completed on time due to the cost of materials, which have been on the increase.

The alternative material used for constructing building wall in Nigeria is earth brick stabilized with agricultural wastes like rice husk, palm kernel fibre and palm tree ash, this is due to high cost of other building material in order to minimized housing problem in Nigeria. The housing problem seems to be getting worse. According to the Federal Mortgage Bank of Nigeria (FMBN, 2019), Nigeria's housing gap is estimated to be in the region of 17 million units while home ownership is estimated as low as 25%. This is as the result of high cost of building materials "Housing deficit" refers to the number of shelters which do not have adequate conditions to be habitable, plus the number of housing units that need to be built to shelter all families who currently lack one and as a result share a shelter with another household in overcrowded conditions (Emanuel, 2019) [1]. It has been identified that 75% of the housing deficit in Nigeria is concentrated on families earning less than three times the minimum wage caught in the poverty cycle, family's income is structurally limited and as a result they are unable to afford proper housing (World Bank, 2013) [4].

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) [5] reported that the waste material, palm ash has been introduced as a competent binder in enhancing mortar and concrete properties.

Water penetration test a method to assess the resistance to rain water penetration (Vilató, 2012) [9]. Water penetration into brick masonry walls leads to several problems such as efflorescence, mortar joint deterioration, interior moisture damages The durability of a brick is determined by abrasion resistance test, abrasion resistance test is a test method that measure the relative abrasion resistance of standard conditions at room temperature. The abrasion resistance of a material provides an indication of its suitability for service in abrasive or erosive environment.

Abrasion testing is a necessity for manufacturers who are interested in producing high-quality products with a long lifespan. With a multitude to different testing methods available, each with their own nuances, it can be difficult to decide which test to use (Alan, 2017) [8].

Nigeria Building and Road Research Institute (NBRRI) proposed the following minimum specifications as requirements for laterite bricks: water absorption of 12.5% and a durability of 6.9% (Raheem *et al*., 2012) [7]. It is obvious that there is 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 needs 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 commodities in the construction sector because of its ability to bind the constituents into a single unit for building purpose. High demands of cement make it costly and inaccessible to the vast majority of people in developing countries like Nigeria where more than half of the population lives in poverty. This have certainly made decent accommodation beyond the reach of many people (Kareem *et al*., 2014) [6].

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 in order to make housing accessible for low-income earners.

Aim and Objectives of the Study

The study aimed to compare the effect of Palm Kernel Fibre, and Palm Leaf Ash on characteristic properties of compressed laterite earth brick. Specifically, the study:

1. Determined the determined the water penetration rate of compressive laterite brick stabilized with palm leaf ash and palm kernel fibre
2. Compared the abrasion resistance of compressed laterite Brick stabilized with palm kernel fibre and Palm Leaf Ash.

Research Questions

The following research questions guided the study:

1. What is the water penetration rate of compressive laterite brick stabilized with palm leaf ash and palm kernel fiber?
2. What is the abrasion ristance of compressed laterite brick stabilized with palm kernel fibres and Palm Leaf Ash?

Materials and Methods

Research Design

This chapter describes research design, area of study, materials used, production of compressed laterite earth bricks, test carried out, and the procedures adopted for the collection of data for the study

The study adopted experimental Research design. According to Patrick (2015) [10] 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 CELB's were obtained locally, manually operated compression machine of 222mm×100mm×70mm was used. Laterite was used for the production of. 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 over size materials from the laterite sample using a wire mesh screen with aperture of about 5.0mm in 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. Water penetration test
2. Abrasion resistance test test

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 was measured
2. The measured laterite and palm kernel fibre 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 palm leaf ash was 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 tests carried out

1. Water penetration test
2. Abrasion resistance test

Procedure for water penetration test of compressed stabilized laterite brick

1. The brick samples was weighed and noted (M1)
2. The weighed samples were sprayed with water for 6 hours (considering duration of rainfall in bida).
3. The weight of the wet brick samples were taken and noted as (M2)
4. The weight m1 and M2 was calculated to get water penetration rate.

Procedure for durability test of compressed stabilized laterite brick

1. The durability of the bricks was determined through abrasive test after the compressed laterite bricks have attained the specified age:
2. Three bricks were weighed and their weight recorded as A1.
3. The bricks were placed on a smooth and firm surface and then wire-brushed to and fro on all the surfaces for 60 times, to and fro making a stroke.
4. The bricks were weighed again and recorded as A2 to determine the amount of material or particles abraded. This procedure was repeated for all bricks produced at various PKF and PLA contents.

Water penetration rate test Compressed Stabilized Laterite Brick

This formula was adopted water absorption rate

$$\text{Water penetration} = \frac{m_1 - m_2}{M_1} \times 100$$

M_1= weight of the dried brick
M_2= weight of the wet brick
The result of percentage of palm leaf ash stabilized brick and palm kernel fiber stabilized brick was compared

Durability test Compressed Stabilized Laterite Brick

This formula was adopted durability rate

$$\text{Abrasion resistance} = \frac{M_2 - M_1}{M_1} \times 100$$

M_1= weight of the brick before abrasion
M_2= weight of the brick after abrasion
The result of percentage of palm leaf ash stabilized brick and palm kernel fiber stabilized brick was compared

Results and Discussion

Research Question One

What is the resistance water penetration rate test of compressed laterite Brick stabilized with palm kernel Earth fibre and Palm Leaf Ash?

Table 1: The results of water penetration test of compressed laterite brick stabilized with palm kernel fibre.

No	%	W1(g)	W2(g)	W3 (%)	W4 (%)
1	1	3.42	3.74	9.36	10.18
2		3.31	3.71	12.08	
3		3.41	3.72	9.09	
4		3.40	3.75	10.29	
5	2	3.28	3.74	14.02	11.52
6		3.41	3.76	10.26	
7		3.29	3.69	12.16	
8	3	3.34	3.72	11.38	12.19
9		3.30	3.73	13.03	

%= the percent of the PKF
No= Number of the bricks
W1 = Weight of dry brick
W2 = Weight of wet brick
W3= water absorption rate
W4= average water absorption rate
The result in table 1 of laboratory test revealed the water penetration rate of compressed laterite brick stabilized with palm kernel fiber stabilization is 10.32% for 1% stabilization, 12.60 for 2% stabilization and 15.53% for 3% stabilization.
These result showed that only 3% stabilization that does not conform to NBRRI specification as 0% dissolve in water.

Table 2: The results of water penetration test of compressed laterite brick stabilized with palm leaf ash.

N	%	W1 (g)	W2 (g)	W3 (%)	W4 (%)
1	5	3.32	3.64	9.64	11.58
2		3.29	3.69	12.16	
3		3.32	3.75	12.95	
4		3.30	3.65	10.60	10.63
5	10	3.23	3.60	11.46	
6		3.31	3.64	9.97	
7		3.28	3.65	11.28	
8	15	3.25	3.57	9.85	10.27
9		3.31	3.63	9.67	

%= the percent of the PLA
No= Number of the bricks
W1 = Weight of dry brick
W2 = Weight of wet brick
W3= water absorption rate
W4= average water absorption rate
Table 2 showed the laboratory test result of Water absorption rate of compressed laterite brick stabilized with palm leaf ash to be stabilization, 12.65 at 5% stabilization,

12.16% at 10% stabilization, and 11.88% at 15% stabilization.
All the bricks are in conformity with NBRRI specification of 12.5%.

Research Question Two
What is the resistance abrasion effect of Compressed Stabilized Laterite Earth Brick Stabilized with Palm Kernel Fibre and Palm Leaf Ash?

Table 3: The results of abrasion test of Compressed Stabilized Laterite Brick Stabilized with Palm Kernel Fibre at 28 days

No	%	M1 (g)	M2 (g)	M3 (%)	M4 (%)
1	1	3.42	3.37	1.48	1.40
2		3.41	3.36	1.49	
3		3.32	3.28	1.22	
4	2	3.39	3.35	1.19	
5		3.49	3.43	1.75	1.27
6		3.40	3.37	0.89	
7		3.45	3.40	1.47	
8	3	3.38	3.32	1.81	1.68
9		3.45	3.39	1.77	

No = Number of the bricks
% = the percentage of PKF
M1 = the mas of the brick before abrasion
M2 = the mas of the brick after abrasion
M3 = the abrasion resistance of the brick
M4 = The average of abrasion resistance of the brick
Table 3 showed the laboratory test result of abrasion resistance of compressed laterite brick stabilized with palm kernel fiber to be 6.38% at 0% stabilization, 3.63% at 1% stabilization, 4.95% at 2% stabilization, and 5.26% at 3% stabilization.
The abrasion resistance results fall within the NBRRI specification of 6.9%.

Table 4: The results of abrasion test of Compressed Stabilized Laterite Earth Brick Stabilized with Palm Leaf Ash at 28 days

No	%	M1 (g)	M2 (g)	M3 (%)	M4 (%)
1		3.50	3.43	2.04	
2	5	3.42	3.34	2.40	2.39
3		3.39	3.30	2.73	
4		3.38	3.30	2.42	
5	10	3.35	3.28	2.13	2.22
6		3.37	3.30	2.12	
7		3.40	3.32	2.41	
8	15	3.39	3.31	2.42	
9		3.36	3.29	2.13	2.32

No = Number of the bricks
% = the percentage of PLA
M1 = the mas of the brick before abrasion
M2 = the mas of the brick after abrasion
M3 = the abrasion resistance of the brick
M4 = The average of abrasion resistance of the brick
The result in table 4 shows the abrasion resistance of compressed laterite brick stabilized with palm kernel fiber is 2.39% at 5% stabilization, 2.22% at 10% stabilization, and 2.32% at 15% stabilization.
These result shows high abrasion resistance which falls within the NBRRI specification.

Summary of Findings: The following findings were made findings and are presented in sequential order of the research questions

1. Bricks stabilized with palm kernel fiber has water penetration rate of 10.18 at 1%, 11.52 at 2% and 12.19 at 3% while the bricks stabilized with palm leaf ash has water penetration rate of 11.58 at 5%, 10.63 at 10% and 11.27 at 15%. This showed that bricks stabilized with PLA produced higher water penetration resistance.
2. Bricks stabilized with palm kernel fiber has abrasion resistance of 1.40 at 1%, 1.27 at 2% and 1.68 at 3% while the bricks stabilized with palm leaf ash has abrasion resistance of 2.39 at 5%, 2.22 at 10% and 2.32 at 15%. This indicated that the bricks stabilized with PKF produced higher abrasion resistance.

Discussion of Findings
The findings of research question one showed that the water penetration rate of the stabilized compressed laterite brick with palm kernel fibre is 10.32, 12.60 and 15.53 as shown in table 4.1 meet the standard specification of 12.5% at one, two and three percent stabilization. NBRRI. It was observed that the water absorption rate was decreasing as the percentage of the fiber stabilization increases. This is in agreement with Ugwuishiwu *et al.* (2013) [11] that water absorption increased with fiber content increased
While the result of stabilized compressed laterite brick with palm leaf ash as showed in table 4.2 that is 12.65%, 12.16% and 11.88% meet the standard specification of NBRRI 12.5%, but the water absorption rate increases as the percentage of palm leaf ash increase. This result was expected because the palm leaf ash binds the laterite particles together and thereby reduces the sizes of the pores through which water could flow into the bricks. This is in line with Raheem *et al.* who's results shows that Interlocking blocks produced with Idioro laterite exhibited the lowest percentages of water absorption of 7.62%, 5.23% and 5.01% for blocks with 5%, 10% and 15% cement stabilisation, respectively. This indicated that water penetration decreases with increased percentages of stabilisation. These results showed that palm bricks stabilized with palm leaf ash has better water resistance than the bricks stabilized with palm kernel fiber.
The findings on research question five (table 4.3) indicated that the abrasion resistance of the bricks stabilized with palm kernel fibre is 6.38 at 0% stabilization, 1.47% at 1% stabilization, 1.8% at 2% stabilization, and 3.67% at 3% stabilization. This indicated that, palm kernel fiber is a qualitative stabilizer for compressed laterite brick. There is increase in the abrasion resistance as the percentage of the stabilizer increases stabilization at 3% produced the lowest abrasion resistance of 3.67. Meanwhile, 1%, 2% and 3% has high abrasion resistance and are in conformity with the standard specification of NBRRI of 6.9%, This is also in line with Raheem *et al.* (2012) [7] who's study showed that the resistance of the blocks to abrasion increases with the addition of the stabilising agent. A high percentage of material was abraded away from laterite interlocking blocks that were not stabilised with cement (the control) while the bricks stabilised with palm leaf ash reduces in the abrasion resistance as the percentage of the ash increases but still in conformity with the NIS standard of 6.9. Table 4.4 showed that the abrasion resistance of the bricks stabilized with palm leaf ash is 3.63% at 5%, 4.95% at 10% and 5.26% at

15%. The abrasion resistance increases as the percentage of palm leaf ash keeps increasing and the result of each percentage meet the standard specification of NBRRI of 6.9%, this indicate that palm leaf ash can improve the abrasion resistance of compressed laterite brick. This is in line who's result showed that Improved Stabilized Lateritic Brick (ISLB) offer resistance to abrasive forces relative to the concentration of the Zycosil Water Solution (ZWS) used in its production; that is, the higher the concentration of ZWS the higher the resistance offered by the brick against abrasive forces. ISLB produced with ZWS of 1:100 have abrasion value of 1.0%, CSLB have abrasion value of 3.0% and AULB have abrasion value of 12%. These results showed that bricks stabilized with palm kernel fibre has better abrasion resistance than bricks stabilized with palm leaf ash.

Conclusion

Based on the study it was concluded that The water absorption rate of compressed laterite brick stabilized with PKF meet the standard specification of NBRRI of 12.5% except 3% stabilization, therefor the laterite bricks stabilized with PKF at 1.0% and 2.0% can be used for building of house. Compressed laterite brick stabilized with PLA have water absorption rate of 10.58% at 5.0% stabilization, 11.63% at 10% stabilization and 11.27% at 15% stabilization which are in conformity with the standard specification of NBRRI.

The abrasion resistance of compressed laterite brick stabilized with PKF at 1%, 2% and 3% have high abrasion resistance considering NBRRI specification of 6.9. This guaranty those walls build by compressed laterite bricks stabilized with PKF will be durable there by, reducing the cost of the production. While the abrasion resistance of compressed laterite brick stabilized with PLA at 5.0%, 10% and 15% have high abrasion resistance considering NBRRI specification of 6.9 but lower than the abrasion resistance of the bricks stabilized with PKF.

Recommendations

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

1. Building professionals should sell these 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 environmentally friendly and cheap.
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.
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.

References

1. Emmanuel AM. Addressing housing deficit in Nigeria: Issues, challenges and prospects. Central Bank of Nigeria, Economic and Financial Review. 2019;57:201-213.
2. Akanni PO, Oke AE, Omotilewa OJ. Implications of Rising Cost of Building Materials in Lagos State Nigeria. Journals Sagepub. 2014;2(9):823-3234.
3. Idoro GI, Jolaiya O. Evaluating material storage strategies and their relationship with construction project performance. Proceedings of CIB International Conference on Building Education and Research, University of Cape Town; c2010. p. 103-113. Retrieved from http://www.rics.org/cobra
4. World Bank. Affordable and Sustainable Housing of Africa. World Hosing programme report; c2013. p. 32.
5. Walid H, Nuraini C, Moerni SY, Rahmad DS. Growth Shelter Based on GDS-BB Principles for Mandailing Etnic Society in Mountainous Area, North Sumatera, Indonesia, International Journal of Civil Engineering and Technology. 2019;10(2):211-221.
6. Kareem JN, Idowu A, Sode O. Analysis of the contribution of imported and locally manufactured cement to the growth of gross domestic product (GDP) of Nigeria (1986- 2011). African Journal of Business Management. 2014;7:360-371.
7. Raheem AA, Falola OO, Adeyeye KJ. Production and Testing of Lateritic Interlocking Blocks Journal of Construction in Developing Countries. 2012;17(1);33-48.
8. Alan J. Understanding the Different Types of Abrasion Testing. Insight from Industires Utility Japan; c2017. p. 45-98.
9. Vilató RR. water penetration test on concrete block masonry 15th International Brick and Block Masonry Conference Florianópolis – Brazil; c2012.
10. Patrick NL, Uphie FCM, Kamseu E, Arlin BT. Laterite Based Stabilized Products for Sustainable Building Applications in Tropical Countries: Review and Prospects for the Case of Cameroon, Sustainability, MDPI, Open Access Journal. 2015;3(1):45-98.
11. Ugwuishiwu BO, Mama BO, Okoye NM. Effects of natural fiber reinforcement on water absorption of compressed stabilized earth blocks. IJSR Int. J Sci. Res. 2013 Nov;2:165-167.