Current Journal of Applied Science and Technology

40(12): 12-22, 2021; Article no.CJAST.68014
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Stabilization of Earth Block Using Rice Husk Ash as Partial Replacement in Cement

S. E. Ubi[1], P. O. Nkra[2] and R. B. Agbor[3*]

[1]Department of Civil Engineering, Cross River University of Technology, Calabar, Nigeria.
[2]Civil and Building Department, Standards Organization of Nigeria, Rivers / Bayelsa State Office, Port Harcourt, Nigeria.
[3]Environmental Biotechnology Unit, Department of Genetics and Biotechnology, University of Calabar, Calabar, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Authors SEU and PON designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RBA managed the analyses of the study. Authors RBA and PON managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2021/v40i1231377
Editor(s):
(1) Dr. Mohammad Abass Ahanger, Institute of Plant and Microbial Biology Academia Sinica, Taiwan.
Reviewers:
(1) Mohd Salahuddin Mohd Basri, Universiti Putra Malaysia, Malaysia.
(2) Mr. K. Mukilan, Kalasalingam University, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/68014

Original Research Article

Received 20 March 2021
Accepted 25 May 2021
Published 02 June 2021

ABSTRACT

The most outstanding problem militating the production of earth block in Nigeria, is the exorbitant prices of cement, rice ash replaced with cement, stabilized compressed earth block to carry load. The main objective of this study was to investigate the sustainability of earthen construction block with a partial replacement of cement using Rice Husk Ash (RHA). RHA is a bye-product material obtained from the combustion of rice husk which consists of non-crystalline silicon dioxide with high specific surface area and high pozzolanic reactivity using a set of sieves 3.35um - 63um, weigh balance, oven maintained at a temperature of 105°C and 110°C, six meta trays, a bucket, a soap, wire brushes, and a mechanical shaker. It is used as pozzolanic material in earth block. Testing specimen were determined and examine in structural composition by means of unconfined compressive strength hydraulically compressed for crushing the composition of mix with RHA content ranges from 10% to 50% to respectively. The result of the compressed earth block shows a significant resistance of shear strength of 30 to 90 kg/mm^2, proving that stabilized earth block can satisfactorily carry load when structurally loaded and can resist tensile and compressive stresses.

**Corresponding author: E-mail: agborreagan@yahoo.com;*

Keywords: Cement; rice; ash; concrete; stabilization.

1. INTRODUCTION

Rice plants absorbs silica from the soil and assimilates it into its structure during its growths, Rice husk is the outer covering of the grain of rice plant with a high concentration of silica. The non-crystalline silica and high specific surface area of the RHA are responsible for its high pozzolanic reactivity [1]. RHA has been used in lime pozzolana mixes and could be a suitable partly replacement for Portland cement [2]. Due to the burning desire of modern technology to exhibit the use of lateritic material for effective use in the engineering industry the use of pozzolans and composite material has been the interest of engineering to put threes material into practical use by means of practical or direct replacement of this engineering material in the modern days technology [3]. This is to enable man to utilize resources found around him in an age of unavailability of construction materials. Lateritic material generally exhibits undesirable engineering properties they tend to have low shear (strength and to lose shear strength, further upon wetting or other physical disturbances [4]. For example, a cohesive lateritic material can creep overtime under constants load especially when the shear stress is approaching its shear strength making them prone to sliding as a result develops large lateral pressures and they tend to have low resilient modulus values for these reasons lateritic clay material are generally poor material for construction purposes. For these reasons they need to be stabilized partially or fully by replacing with rice husk ash, as an effective material for construction [5]. The use of rice husk ash for long term performances in earth block often rely on the stability of the block. This stabilization was done in three different means; thermal, electrical, chemical or mechanical means. Also, by densification through compaction of the soil, a system by which a soil can gain density by application of mechanical energy, by means of expelling air from soil without much change in water content [6]. In many cases construction material cost, account for low house ownership by individuals and construction of substandard houses in Nigeria, earth material does not always qualify to be used directly as a construction material instead it requires improvement on their engineering properties in order to achieve the target strength requirement set for earth-block material [7] and [8]. The purpose is to treat the problem, improve on many signification means by using chemical stabilizers, composite or Pozolans, to accelerate for improvement of the engineering properties. RHA has a partial stabilizer interactions with the complexity among many varying lateritic soils not depending on the heterogeneity in soil composite. According to [9], for masonry unit in building construction "approximately 10% of cement for the stabilization of earth block, this is a means of providing strength to the blocks and preventing cracking. It is a process also used to increase and maintain the natural strength of the block by means of achieving the bearing capacity of the engineering material used for civil engineering practices. Rice husk ash has a partial replacement for the stabilization of traditional clay to alternatively replace Portland cement as a pozolans material partial for stabilization. Akinmusuru, [9], evaluated the potentials of fly ash admixture to stabilize the effectiveness of expansive soil. It was discovered that the plasticity index activity, free swell potential swelling pressure, and axial shrinkage percent of the soil decreased when fly ash added in a reasonable quantity. Okafor and Okonkwo [10] used rice husk to reduce the plasticity of a lateritic soil and improve the geotechnical properties of the soil effectively. Asha et al. [11] examined the performance of compressed stabilized earth blocks with rice husks ash and observed that the unit weight of blocks decreased with increase in percent of rice husk ash. It was reported that when the plasticity is reduced, there is increase in volume of the stability and strength of the soil. From their findings it was revealed that they exist a significant feasibility on the usage of Rice Husk Ash as a partial replacement of cement in the stabilization of clay soil for the production compressed earth. Hence, the aim of this paper was to enhanced mechanical activities to the public in order to restore efficacy in construction works using rice husk ash partially replacement that is widely acceptable among the populace.

2. MATERIALS AND METHODS

Investigations were carried out to select a lateritic soil material from a borrow pit for testing. A typical lateritic clay material that conforms to the requirement of the research through data analysis was generated from both the field and laboratory.

2.1 Sampling of Lateritic Soil

Direct observation of the sub-surface condition and retrieval of field samples were achieved by examination of soil formation using accessible excavation. By providing test pits of 2x1.5m to obtain cares samples. The disturbed bulk samples were taken in the predominantly brownish grey salty clay deposit that generally underlines the site.

2.1.1 Sampling/particle size distribution of rice husk ash

Materials were obtained from the burning of a milling rice husk in an open air with specific gravity of 1.78 and a bulk density of 0.54 using a weight of 4.5. Thereafter, sieve analysis method was used to determine the particle size distribution of rice husk ash. This was carried out using different sieves, and the weight of different sieves size were measured and tabulated against their corresponding sieves as (w1). The weight of sieve plus the sample of rice husk ash retained on the sieve was recorded as (w2). The weight of samples retained from each of the sieve's size was determined by subtracting the weight of the experimental test. It was then computed for the various weights of samples; while the percentage passing was obtained by subtracting the cumulative weight of sample retained from 100%.

2.1.2 Bulk density of rice husk ash

The apparatus used for this test was a cylinder weighing 6kg having a volume of 0.00325m^3. The cylinder was filled with rice husk ash and compacted with a rammer until it was leveled and the weight of cylinder plus sample was determined using the weighing balance and was recorded as T, the bulk density was determined mathematically using the relation Bulk density =

$$\frac{T-6}{\text{Volume of cylinder}} \quad (1)$$

2.1.3 Specific gravity of rice husk ash (RHA)

The container used for weighing was recorded as (w1). The container was then filled with a sample of rice husk ash and measured on a weighing balance and recorded as (w2). The container retaining the sample of (RHA) was filled with water and weighed in the weighing balance as (w3). The weight of dried sample was obtained by subtracting (w3-w2) to obtain (w4). The weight of dried sample was obtained by subtracting (w1-w2) and was recorded as (w5). The weight of water was calculated by subtracting (w2-w3) to obtain (w4), the weight of the dry sample was obtained by subtracting wl from w2 (wl-w2) and was recorded. The weight of water was calculated by subtracting w2 from w3 and recorded as (Gs). Therefore, the specific gravity =

$$\frac{GS = w_2-w_1}{(w_4-w_1) - (w_3-w_2)} \quad (2)$$

2.2 Properties of Rice Husk Ash

From the work of Oyetola and Abdulahi [12], the iron (iii) oxide (Fe2O3) and aluminum oxide (A12O3) were found to be 73.15%. This value is below the minimum requirement of 70% by the American standard for testing materials (ASTM), Oxide has about 67.3% followed by aluminum oxide with 4.90%. The specific gravity of rice husk ash was 2.13 which is within the range of pulverized fuel ash (PFA), which is 1.9 - 2.4. It also revealed that the block densities compacted and uncompact to be 530kg/m^3 and 460kg/m^3 respectively.

2.3 Moisture Content Procedure

It performing the test, it was done in accordance with the BS 1377:1990. And the material use for the testing was taken to the laboratory and was sealed in an approved and accepted container without delay. However, the oven dried take a minimum period of 28 days before testing.

2.4 Specific Gravity Laterite

Specific gravity of soil particles was conducted according to the procedure in BS 1377 1990 the pycnometer method bottle was used about 500g of soil sample were weigh and the soil S. G. determination done by displacing particle of soil in water by the weight.

2.5 Liquid Limit/ Plastic Limit

The method employed were in accordance with the method down in B.S, 1377:1990. The material was measure to about 500g- 400g. After a period of soaking the material was then mixed with a spatula given some blows ranging from 14 - 50 plows early disturbed at five points. The plastic limits were mixed in a glass plate and the soils were roll to 3mm in diameter and the materials were taken at average of three tests.

2.6 Particle Size Distribution

The test was carried out in the same procedure given in the general standard above B.S. sieve were used, the weighed of individual grain particles retained were weighed in the range of the sieve size. The fractions of particle were calculated plotted in logarithmic scale.

2.7 Stabilized Compressed Earth Block

Stabilized earth blocks are manufactured by compacting ram material earth mixed with a stabilizer. For instance, the application of cement with rice husk ash, under a pressure of 20-40 leg/cm^2 using manual soil press such as a rammer, the principles applied the compaction of new earth to attain dense, even sized masonry. The hydraulic machine used the manufactured interlocked blocks which is highly suitable for speedy and mortar less construction stabilized compressed earth block.

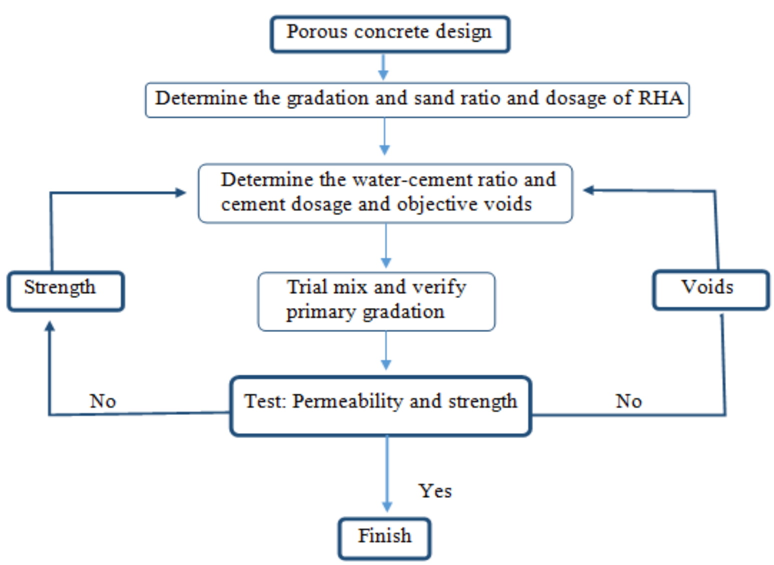
The compressed earth blocks are sundries and use cement and replaced with rice husk ash as stabilization for gaining the required strength.

2.8 Curing

The setting time and hardening of cement depends on water. It has been a subsequent gaining to achieve the strength of the earth block after setting, it is primarily a function of the curing regime, which in turn determines the space of the hydration process. The study adopted the water curing method involving the promotion of hydration, domination of shrinkage and absorption of the heat of hydration. This act keeps the surface of the concrete moist by the use of ponding, spraying/sprinkling, damp sand or dam hessian. Here, the cube was sprinkled with water every day for about 40days to enable proper hydration of the cement to take place.

2.9 Mix Design and Production of Block

For the purpose of this study, about 66 (150mm x l50mm) earth blocks were produced. The quantities of materials obtained from the mix design were measured in each case with the aid of weighing balance. The cement and rice husk ash (RHA) were mixed thoroughly. The sand was poured on to the concrete floor in the concrete laboratory. The cement, RHA and sand were then mixed together to obtain a homogeneous mixture. The measured quantity of water was then sprinkled on to the mixture using bucket. The mixture was further turned with shovels until a mix of the required workability was obtained. This was tamped uniformly over the cross section of the mould with 25 strokes with a tamping bar. More mortar was added and tamped until the mould was completely filled to the brim. The content was demoulded in the concrete laboratory as a fresh earth block. The block samples were cured by sprinkling water twice in the morning and evening daily as highlighted in Fig. 1.



Chat 1. Mixture Design of RHA

3. RESULTS AND DISCUSSION

The replacement levels and water/binder ratios used are as shown on Table 1. A mix design was carried out by absolute volume method to select the most suitable materials (cement, RHA, laterite and water) that will produce blocks with the desired properties (Table 2).

3.1 Moisture Content Test

Table 3 shows that the particles size distribution for laterite has a wet weight of 875g, dry weight of 520g, average size of laterite is 0.600mm and a moisture content of 12.5% as shown below on Table 3 & Fig. 1. The liquid limit of 46.5%, plastic limit of 30.0% and plasticity index of 16.5% as displayed on Table 4 and Fig. 2. The lateritic soil contains substantial quantity of dryness and this is a well-known phenomenon of a particular clay that concerns expansive clay materials (such as montmonllonti etc.) were obtained while the test for dry density GM/CMMG/M3 is showed in Table 5 and Fig. 3 respectively.

3.2 Compressive Test

Table 6, showed the unconfined compressed earth block with addition of 5-10% cement and 10%-20% of rice husk ash easily pass the uniform building standards for compression with an average of 960kg/cm^2. The rammed earth block tested with a compressive strength of 30 to 90 kg/mm^2 as cement is added compressive strength increases. The result imply that the compressive strength generally increases with age at curing and decreases as the RHA content increases (see Basri, M. S. M., Mazian, N., Mustapha, F., & Ishak, M. R. (2017). Correlation between compressive strength and fire-resistant performance of rice husk ash-based geopolymer binder for panel application. In MATEC Web of Conferences (Vol.97, P. 01025) EDP Sciences; Kusbiantoro, A., Nuruddin, M. F., Shafiq, N., & Qazi, S. A. (2012). The effect of microwave incinerated rice husk ash on the compressive and bond strength of fly ash based geopolymer concrete. Construction and Building Materials, 36, 695 – 703; and Salahuddin, M. M. Azlan, N., Ustapha, F., Ishak, M. R. & Saprudin, A. A. (2020). Factorial design approach to investigate the significance of factors on the fire resistant, compression and adhesion properties of geopolymer binder. Journal of Mechanical Engineering and Sciences, 14(3), 7191 – 7204).

Table 1. Percentage replacement Levels & water/binder ratio

Replacement level [%]	Water/binder ratio
100% OPC, 0% RHA	0.50
90% OPC, 10% RHA	0.54
80% OPC, 20% RHA	0.55
70% OPC, 30% RHA	0.56
60% OPC, 40% RHA	0.57
50% OPC, 50% RHA	0,58

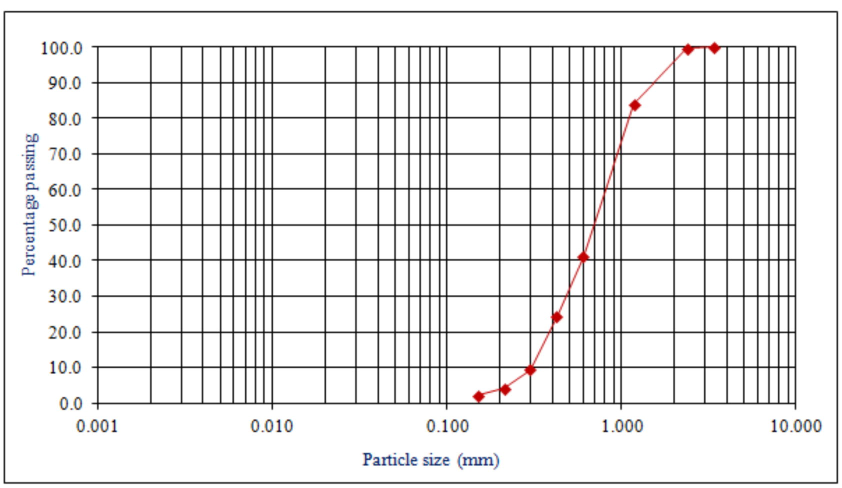


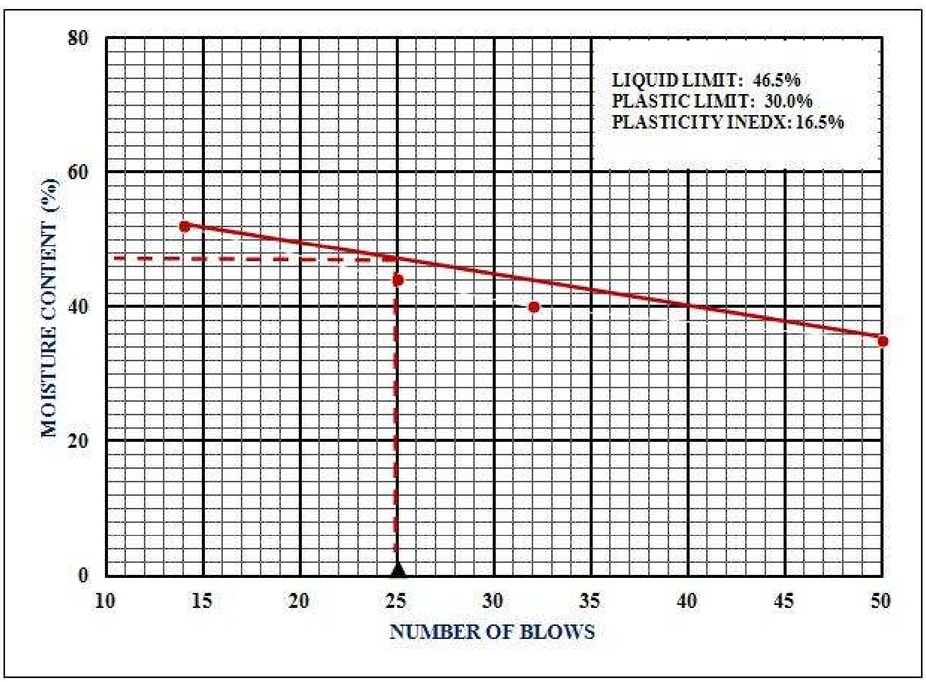
Fig. 1. Particle size distribution of laterite

Table 2. Parameter of lateritic soil

Soil parameter	Test result
Specific Gravity	2.12
Liquid Limit LL (%)	44.0
Plasticity Limit PL (%)	30.0
Plasticity Index PI (%)	14.0
Linear Shrinkage (%)	16.0
Maximum Dry Density (kg/m^3)	1.80
Optimum moisture content (%)	16.8
Percent passing BS No200 sieve	25.0
AASHTO Classification	A-2-6
USCS Classification	CL

Table 3. Particles sizes distribution for laterite

Sieve (mm)	Mass (g)	% retained	% Cumulative Retained	% passing
20				
14				
10				
6				
5				
3.35				100
2.36	2	0.4	0.4	99.6
1.18	82	15.6	16.0	84.0
0.600	225	42.9	58.9	41.1
0.425	89	17.0	75.8	24.2
0.300	78	14.9	90.7	9.3
0.212	28	5.3	96.0	4.0
0.150	10	1.9	97.9	2.1
0.075	11	2.1	100.0	
Total				



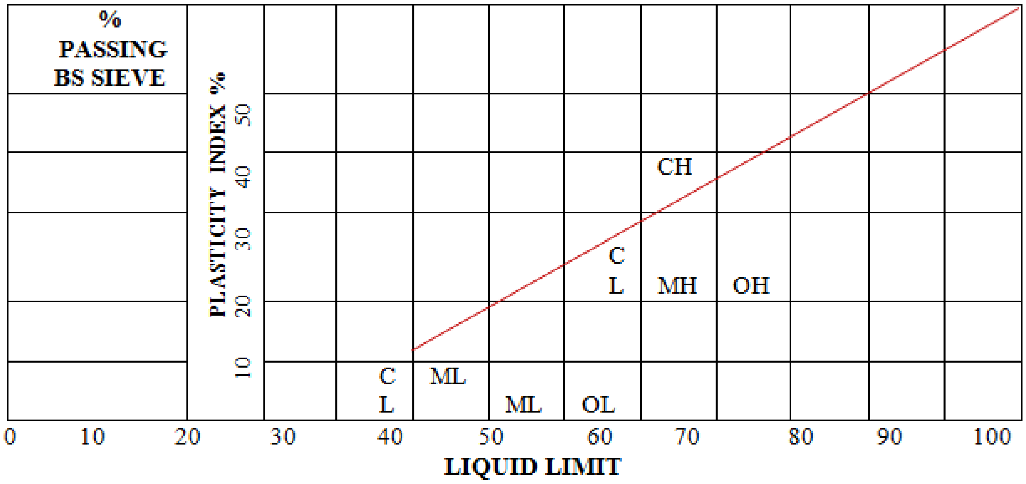


Fig. 2. Showing the moisture content of numbers of blows and liquid limit

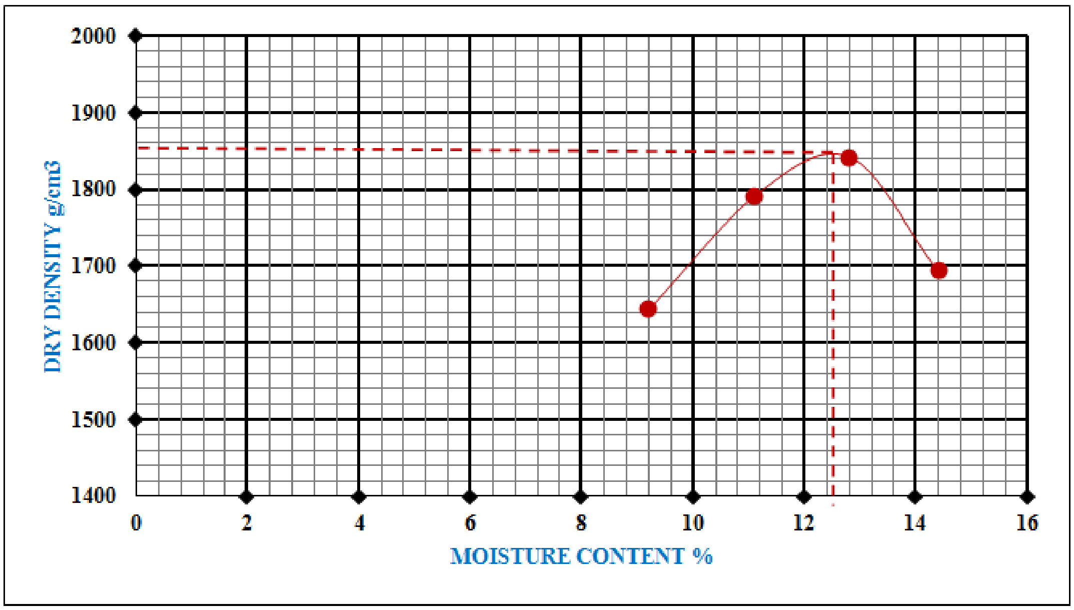


Fig. 3. Showing the moisture content of dry density

Table 4. Liquid limit test

Liquid limit test						Plastic limit test		
At: 25 BLOWS		**LL**	**LL**	**LL**	**LL**			
NUMBER OF BLOWS		14	25	32	50		PL	PL
MOISTURE CONTENT TIN NUMBER		1	2	3	4		M	N
WEIGHT OF TIN + WET SOIL (g)		25.0	21.0	22.0	23.0		21.1	21.1
WEIGHT OF TIN + DRY SOIL(g)		19.0	17.0	18.0	19.1		18.1	18.1
WEIGHT OF TIN (g)		8.0	8.0	8.0	8.0		8.0	8.0
WEIGHT OF WATER (g)		5.8	4.0	4.0	3.9		3.0	3.0
WEIGHT OF DRY SOIL (g)		11.2	9.0	10.0	11.1		10.1	10.1
MOISTURE CONTENT %		52.0	44.0	40.0	35.0		30.0	30.0
One point method	Factor	Average ll: 42.8%				Av. Pl	30.0%	

Table 5. Moisture density relationship

	Type of mould: Modified Proctor					**Number of layers: 3**				
	Number of blows per layer: 56						**Weight of hammer: 4.5Kg**			
A	Wt of mould + wet soil *(W_1)*	Kg	3.602		3.835		3.909			3.760
B	Wt of empty mould *(W_2)*	Kg	1.638		1.638		1.638			1.638
C	Wt of wet sample *(W_1 - W_2)*	Kg	1.964		2.197		2.271			2.122
D	Wet Density *$P=(W_1 - W_2) / V$*	Kg/m^3	1785		1997		2065			1929
E	Moisture Content	TIN	QA	ZX	SA	DC	QA	ZX	SA	DC
F	Wt of wet Soil +TIN (M)	g	54	57	53	55	54	57	53	55
G	Wt of Dry soil +TIIN (M_2)	g	50	53	49	50	50	53	49	50
H	Wt of Water (M_1 – M_2)	g	4	4	4	5	4	4	4	5
I	Wt of TIN (M_3)	g	8	8	9	9	8	8	9	9
J	Wt of Dry soil *(M_2-M_3)*	g	42	45	40	41	42	45	40	41
K	Moisture Content *(M)*	%	9.52	8.89	10.0	12.2	9.52	8.89	10.00	12.20
L	Mean M/C	%	9.2		11.1		12.8	14.4		
M	Dry Density $GM/CMMG/M^3$	g/cm^3	1.644		1.791		1.842	1.694		

Table 6. Strength results of the unconfined compressive test

Mix ratio	Age at curing [days)	Date of cast	Date of test	Weight of Specimen	Volume of specimen	Density of specimen	Load kn	Area mm^2	Strength
100%	7	09/09/2011	16/09/2011	7632	3375	2.26	50	22.5	2.22
OPC,	14	09/09/2011	23/09/2011	7576	3375	2.24	55	22.5	2.4
0% RHA	21	09/09/2011	30/09/2011	7682	3375	2,27	65	22.5	2.8
	28	09/09/2011	07/10/2011	7780	3375	2.30	80	22.5	3.6
90%	7	07/10/2011	12/10/2011	7317	3375	2.16	50	22.5	2.22
OPC,	14	07/10/2011	21/10/2011	6930	3375	2.05	48	22.5	2.1
10%	21	07/10/2011	28/10/2011	6595	3375	1.95	62	22.5	2.7
RHA	28	07/10/2011	05/11/2011	6287	3375	1.86	75	22.5	3.3
80%	7	05/11/2011	12/11/2011	7582	3375	2.25	45	22.5	2.0
OPC,	14	05/11/2011	19/11/2011	6880	3375	2.04	55	22.5	2.4
20%	21	05/11/2011	26/11/2011	6692	3375	1.92	70	22.5	3.1
RHA	28	05/11/2011	03/12/2011	6353	3375	1.88	100	22.5	4.4
70%	7	03/12/2011	10/12/2011	7632	3375	2.26	52	22,5	2.3
OPC,	14	03/12/2011	17/12/2011	7576	3375	2.24	45	22.5	2.0
30%	21	03/12/2011	24/12/2011	7682	3375	2,27	50	22.5	2.2
RHA	28	03/12/20ll	31/12/2011	7780	3375	2.30	60	22.5	2.6
60%	7	31/12/2011	07/01/2012	7317	3375	2.16	50	22.5	2.2
OPC,	14	31/12/2011	14/01/2012	6930	3375	2.05	40	22.5	1,7
40%	21	31/12/2011	21/01/2012	6595	3375	1,95	48	22.5	2.1
RHA	28	31/12/2011	28/01/2012	6287	3375	1.86	55	22,5	2.4
50%	7	28/01/2012	04/02/2012	7582	3375	2.25	30	22.5	1.3
OPC,	14	28/01/2012	11/02/2012	6880	3375	2.04	35	22.5	1.5
50%	21	28/01/20l2	18/02/2012	6692	3375	1.92	42	22.5	1.86
RHA	28	28/01/2012	25/02/2012	6353	3375	1.88	45	22,5	2.0

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

This study involved the utilization of stabilized earth block using Rice Husk Ash (RHA) as partial replacement in cement. Based on the result of the experimental investigation carried out, the following points can be concluded:

1. Both laterite and rice husk ash can be used as building materials that can totally combined with cement since sulphate totally absent and can be recommended as binder.
2. Direct observation of the sub-surface condition and retrieval of the study field samples were achieved by examination of soil formation using accessible excavation, through the provision of test pits of 2x1.5m to obtain cares samples.
3. The specific gravity of rice husk ash of the study was 2.13 which is within the range of pulverized fuel ash (PFA), which is 1.9 – 2.4 with the block densities compacted and uncompacted to be 503kg/m^3 and 460kg/m^3.
4. It was earth block made with rice husk and laterite produces strength that satisfies the requirement for load bearing wall or member.

4.2 Recommendation

Compressed earth block is used for load bearing construction, the cost of block could depend upon a variety of factors including quality and price of available soil. The amount of stabilization productivity and overhead costs is the degree of stabilization which has the maximum influence on the cost of the product. The advantage is for cost effective, control environmentally friendly conserves agricultural soil and non-renewable fuel, it provides better thermal insulation appealing an esthetic and its elegant profile and uniform size.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Oluremi AA. Input of local materials in buildings as a means of reducing cost of construction. Journal of the Nigerian Institute of Quantity Surveyors. 1990;12-14.
2. Anwar M, Miyagawa T, Gaweesh M. Using rice husk ash as a cement replacement material in concrete; 2001.
3. Dakroury AE, Gasser MS. Rice husk ash (RHA) as cement admixture for immobilization of liquid radioactive waste at different temperatures. Journal of Nuclear Materials. 2008;381(3): 271-277
4. Mbiminah GY. Effects of rice husk on the comprehensive strength and durability of burnt - clay bricks, B. Eng. Project., Department of Civil Engineering, Ahmadu Bello University Zaria, Nigeria; 1992.
5. Michael KO. Rice Husk as stabilizing agents in Clay Bricks, Higher National Diploma Project, Department of Civil Engineering, Federal Polytechnic Bida, Nigeria;1994.
6. Dashan II, Kamang EEI. Some characteristics of RHA/OPC Concretes: A preliminary Assessment. Nigerian Journal of Construction Technology and Management, 1999;2(1):22-28.
7. Mahmud B, Hamid NBAA, Chia BS. High Strength Rice Husk Ash - A preliminary Investigation. In the Proceedings of the 1996 3rd Asia Pacific Conferences on Structural Engineering and Construction. 1996;383-389.
8. Delia VP, Kuhn I, Hotza D. Rice husk ash as an alternate source for active silica production. Materials L. 2002;57(4):818-821.
9. Akinmusuru JO. Mutlibell and block anchor capacities in sand. Soils Found. 1984;24 (4):118–130
10. Okafor FO, Okonkwo UN. Effect of Rice Husk Ash on some Geotechnical Properties of Lateritic soil. Nigerian Journal of Technology. 2009;28(1):48-52.

11. Asha P, Johnson K, Sachin CM, Vetrivel V, Prasanna E. Performance of compressed stabilized earth blocks with rice husk ash. Current Journal of Applied Science and Technology, 2020;39 (25):143-153.

12. Oyetola EB, Abdulahi M. The use of rice ash in low cost sandcrete blocks production. Leonardo Electric Journal practices and Technologies. 2000;8:58-70.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/68014