Cement Stabilized Nsukka Psoriasis Africana-Laterite Blocks for Affordable Housing

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Abstract: - With the current state of the country's global economic meltdown and the ever depleting natural resources and energy source; in addition to the high cost of owning a house, it has become imperative that new creative ways be developed to help salvage the situation and some of the ways developed are to find more abundant, cheaper and stable raw materials for construction. This research was aimed at determining the optimum mix ratio for cement stabilized blocks made with laterite and psoriasis Africana that can effectively replace sandcrete blocks with respect to its compressive strength. In this study we carried out a selective phase of investigation using mud and the plant, psoriasis Africana, in grounded form be stabilized with some specified quantity of cement to form mud block of 100mm x 100mm. Compressive strength for the blocks was determined after curing them for 21 days. The mix ratios for laterite blocks were 1:1.67, 1:2.5, 1:5, 1:6, 1:7, 1:8 and 1:5, 1:6, 1:7, 1:8 for sandcrete blocks. The results showed that psoriasis Africana laterite blocks (PALB) with mix ratio 1:5 which had an average compressive strength of 4.88N/mm^2 can be used in lieu of sandcrete block with mix ratio of 1:6 and average compressive strength of 4.11N/mm^2.

Key Words: — *Cement stabilization, Laterite soil, Psoriasis Africana, Compressive strength, Affordable housing.*

I. INTRODUCTION

Soil stabilization is the controlled modification of soil texture, structure and physico-mechanical properties of the soil. The major reasons for performing soil stabilization include improvement of strength, bearing capacity as well as other engineering properties of soils and to promote the use of waste materials in construction. There are three broad types of soil stabilization: biological, physical and chemical. Biological soil stabilization is achieved through afforestation or planting, and its main purpose is erosion control. Physical stabilization is the modification of soil particle size distribution and plasticity by the addition or subtraction of different soil fractions in order to modify its physical properties. Chemical types of soil stabilization can be achieved through use of traditional and non-traditional agents. The distinction between the two classes exists as a result of the pre-existing and well-established additives as compared to the most recently developed agents. Examples of traditional chemical stabilization agents include lime, cement and fly ash and they are usually calcium based. On exposure to water, they undergo both short- and long-term chemical changes resulting in overall enhancement of the soil matrix with regards to swell reduction, shear strength improvement and resistance to influence of wetting and drying. Cement is the oldest and still very common soil binder. Cement can be used for the stabilization of a wide range of soil types. Laterite is a soil layer that is rich in iron oxide and is derived from a wide variety of rock weathering under strongly oxidising and leading conditions. It forms in tropical and subtropical regions where the climate is humid [1]. Among many basic needs of mankind – rich or poor, is the need for shelter. Despite the importance of shelter to the human race, it is still a Herculean task affording a decent accommodation (house). This is due to the high cost of building materials and partly because of the global economic meltdown in which Nigeria was not spared. Due to these reasons and also because of the depleting natural resources, engineers have been trying to find out ways to use affordable materials. And one of the ways discovered was the use of stabilized laterite blocks instead of cement blocks.

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II. LITERATURE REVIEW

Cement is a good stabilizer for laterite as shown in Ndububa E.E and Malgwi Y.I research which was carried out an experimental investigation of the compressive strength of laterite stabilized with cement (CSL), lime (LSL) and rice straw (RSL) respectively. The results showed that the lateritic soils in the investigated area were relatively high on sand and lower on clay thereby promoting cement as the best stabilizer for strength. It increased the compressive strength by 661% from 0.61 N/mm2 at zero stabilization (ZSL) to 4.64 N/mm2 at 8% cement content after 28 days of curing[2]. In 2020, a study by Tanu et al investigated the use of locally available laterite soil, rice husk ash and areca husk fiber to make paver blocks which is then stabilized using some percentage of cement. The performance of the paver blocks is enhanced by usage of SBR latex. The pavers were cast and tested for compressive strength, abrasion resistance and water absorption. It was observed that the mixture of soil with 20% replacement of rice husk ash and 0.4% addition of areca husk fiber by the weight of soil and ash, with addition of 30% cement and constant 2% latex showed satisfactory results [3]. Komolafe and Osinubi worked on stabilization of lateritic soil with cement – oil palm empty fruit bunch ash blend for California bearing ratio base course requirement. The laterite soil was treated with cement – oil palm empty fruit bunch ash (OPEFBA) blend in stepped concentrations of 0, 2, 4, 6 and 8 % cement as well as 0, 2, 4, 6 and 8 % of OPEFBA, respectively, by weight of dry soil. It was observed that the 2-day CBR values (soaked) of the natural soil for the BSL, WAS and BSH compaction efforts increased from 10, 6 and 8 % to 105, 120 and 110 %, respectively, at an optimum 8 % Cement / 2 % OPEFBA treatment. These CBR values met the 80 % requirement for base course materials with a beneficial environmental advantage of utilizing a palm oil mill waste [4]. Olutoge et al in 2018 researched on the use of lateritic cement- and lime-stabilised bricks and blocks for affordable housing. It was observed that the compressive strengths of cement- and lime-stabilised lateritic bricks and blocks were investigated for economical construction in developing countries. Cement-stabilised lateritic blocks and bricks were found to have the best performance and were recommended for use [5].

III. METHODOLOGY

Materials:

The materials used for this project (research work) are as follows:

- Ordinary Portland cement (Dangote Portland cement)
- Laterite from Paul B construction site in University of Nigeria Nsukka.
- River sand from Opi
- Tap water from the University of Nigeria Nsukka Civil Engineering Laboratory.
- Plant psoriasis africana

Procedure:

Various mix ratios were used for both laterite blocks (stabilized with cement) and the sandcrete blocks. The mix ratios used for the laterite blocks were 1:1.67, 1:2.5, 1:5, 1:6, 1:7, 1:8 while the mix ratios for sandcrete blocks were 1:5, 1:6, 1:7, 1:8. The plant, *Psoriasis Africana*, was added to the laterite before mixing with cement. The cubes used in casting were of dimension 100 x 100mm. The cubes are metallic and grease was applied on the inner part of the cubes to enable the casted blocks to b e demoulded easily. The cubes for both laterite blocks and sandcrete blocks were casted; two cubes were casted for each mix ratios and after a day were demoulded and cured for 21 days. After the 21 days of curing they were crushed using the crushing machine and their readings taken.

IV. RESULTS AND DISCUSSION

A. *Moisture Content Test Result*

Table.1. Moisture Content Test for Laterite

Moisture can number	52	51	61
Weight of moisture can (g)	14.95	15.75	16.00
Weight of moisture can and wet soil (g)	21.50	21.20	20.75
Weight of moisture can and dry soil (g)	20.75	20.50	20.00
Weight of water (g)	0.75	0.70	0.75
Weight of dry soil (g)	5.80	4.75	4.00
% of moisture content	12.90	14.70	18.80

Average moisture content (%)

$$= \frac{12.90 + 14.70 + 18.80}{3} = 15.47$$

Table.2. Moisture Content Test for Sharp Sand

Moisture can number	10	65	86
Weight of moisture can (g)	16.90	16.80	16.00
Weight of moisture can and wet sample (g)	40.00	42.50	38.40
Weight of moisture can and dry sample (g)	39.70	42.40	37.70
Weight of water (g)	0.30	0.10	0.70
Weight of dry sample (g)	22.80	25.60	22.40
% of moisture content	1.31	0.39	3.12

$$\text{Average moisture content (\%)} = \frac{1.31+0.39+3.12}{3} = 1.61$$

B. Specific Gravity Results

Table.3. Specific Gravity of Sharp Sand

Density bottles label	A	B
Mass of density bottle and stopper (g)	22.10	29.60
Mass of density bottle and stopper and content (g)	36.60	42.50
Mass of density bottle and stopper and content and water (g) (W_B)	80.90	86.50
Mass of density bottle and stopper and water only (g) [W_A]	72.10	78.65
Mass of content (g) [W_o]	14.50	12.90

For density bottle A:

$$\text{Specific gravity} = \frac{14.50}{14.5-72.1+80.9} = 0.62$$

For density, bottle B:

$$\text{Specific gravity} = \frac{12.90}{12.9-78.65+86.5} = 0.61$$

Therefore,

$$\text{Average specific gravity} = \frac{0.62+0.61}{2} = 0.615 \approx 0.62$$

Table.4. Specific Gravity of Laterite

Density bottles label	A	B
Mass of density bottle and stopper (g)	5.50	29.50
Mass of density bottle and stopper and content (g)	14.10	42.95
Mass of density bottle and stopper and content and water (g) (W_B)	35.30	86.80
Mass of density bottle and stopper and water only (g) [W_A]	30.00	78.10
Mass of content (g) [W_o]	8.60	13.45

For density bottle A:

$$\text{Specific gravity} = \frac{8.60}{8.6-30.0+35.3} = 0.619$$

For density B:

$$\text{Specific gravity} = \frac{13.45}{13.45-78.1+86.8} = 0.607$$

Therefore,

$$\text{Average specific gravity} = \frac{0.619+0.607}{2} = 0.613$$

C. Atterberg Limit Test Result

Table.5. Plastic Limit Test Result for Laterite

Moisture can number	2	61
Weight of moisture can (g)	15.70	15.45
Weight of sample and moisture can (g)	16.60	18.50
Weight of dry sample and moisture can (g)	17.10	18.85
Weight of dry sample (g)	1.40	3.40
Weight of moisture (g)	0.20	0.35
Percentage moisture content	14.3	10.3

Table.6. Liquid Limit Result

Number of blows	Moisture can number	Weight of dry sample (g)	Weight of moisture	percentage of moisture
15-20(15)	97	3.40	0.60	17.6
	13	3.60	0.70	19.4
20-30(25)	74	2.70	0.40	14.8
	75	4.35	0.70	16.1
30-40(32)	87	3.95	0.40	10.1
	41	3.20	0.25	7.8
40-50(40)	7	2.75	0.15	5.5
	51	5.15	0.35	6.8

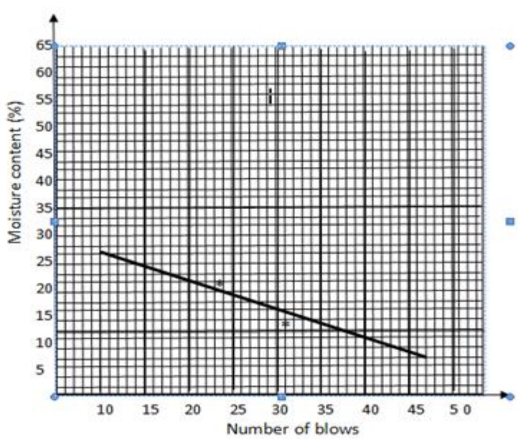

Figure.1. Moisture Content Vs Number of Blows

The liquid limit from the graph above is 13%.

And plastic index (PI) = Plastic Index (PI)

$$\frac{LL-PL}{PL}=\frac{13-12.3}{12.3}=0.057$$

SHRINKAGE LIMIT RESULT

Initial length = 14.0cm

Initial length = 13.5cm

$$Linear\ shrinkage=\frac{14.0-13.5}{13.5}\times 100=3.70\%$$

D. Result of the Sieve Test

Table.7. Result of the Sieve Test for Sharp Sand

Sieve sizes (mm)	Sieve number	Weight of sample (g)	% weight retained (g)	Cumulative % weight retained	Cumulative % weight passing	Zone
2.38	8	22	4.4	4	96	2,3, 4,
2.00	10	9	1.8	6	94	1,2
1.68	12	6	1.2	7	93	2
1.19	16	44	8.8	16	84	2,3
0.774	22	58	11.6	28	72	1,2
0.425	36	23	4.6	32	68	-
0.380	44	165	33.0	65	35	-
0.160	85	154	30.8	96	4	-
pan		19	3.8	-	-	-
		500	250	256		

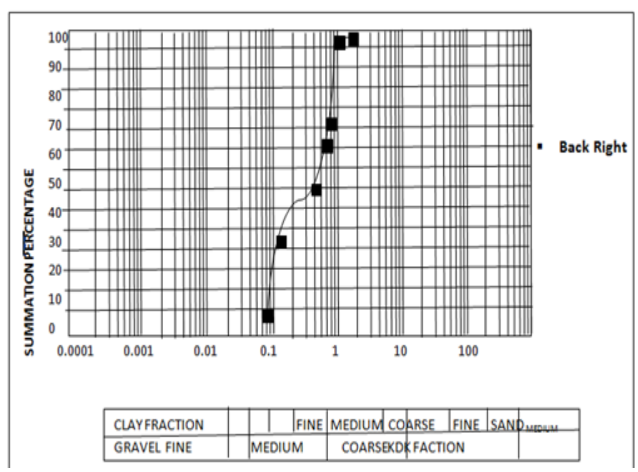

Figure.2. Particle Size Distribution for Sharp Sand

$$fitness\ modulus,\ n = \frac{256}{100} = 2.56$$

$$coefficient\ of\ uniformity, C_u = \frac{D_{60}}{D_{10}} = 3.20$$

$$coefficient\ of\ curvature, C_c = \frac{(D_{30})^2}{(D_{60} \times D_{10})} = 0.80$$

This implies that the sharp sand is poorly graded.

Table.8. Result of the Sieve Test for Laterite

Sieve sizes (mm)	Sieve number	Weight of sample (g)	% weight retained (g)	Cumulative % weight retained	Cumulative % weight passing	Zone
2.36	7	5	1.0	1	99	2,3,4,
1.40	12	12	2.4	3	97	3,4
0.60	25	62	12.4	16	84	4
0.425	36	15	3.0	19	81	-
0.300	52	122	24.4	43	57	-
0.150	100	156	31.2	74	26	-
0.09	170	98	19.6	94	6	-
pan		30	6.0	-	-	
		500				

Table.9. Result of Compressive Strength Test for Sharp Sand

Block Type	Cement Laterite ratio	Compressive Force (kgf)	Compressive Force (N)	Area of Block (mm^2)	Compressive strength (N/mm^2)	Weight (kg)
Sample	-	320	3200	2500	1.280	
C1	1:5	4400	44000	8000	5.500	1.90
		3400	34000	8000	4.250	2.00
C2	1:2.5	5020	50200	7500	6.693	1.80
		6700	67000	7500	8.933	1.90
C3	1:1.67	12060	120600	8500	14.188	1.90
		14200	142000	8500	16.706	1.90
C6	1:6	3425	34250	10000	3.425	1.90
		3175	31750	10000	3.175	2.00
C7	1:7	2226	22260	10000	2.226	1.90
		2613	26130	10000	2.613	2.00
C8	1:8	1718	17180	10000	1.718	2.00
		2005	20050	10000	2.005	2.00

$$fitness\ modulus,\ n = \frac{250}{100} = 2.50$$

$$coefficient\ of\ uniformity, C_u = \frac{D_{60}}{D_{10}} = 1.9$$

$$coefficient\ of\ curvature, C_c = \frac{(D_{30})^2}{(D_{60} \times D_{10})} = 1.07$$

Table.10. Result of Compressive Strength Test for Sharp Sand

Block Type	Cement sharp sand ratio	Compressive Force (kgf)	Compressive Force (N)	Area of Block (mm^2)	Compressive strength (N/mm^2)	Weight (kg)
S5	1:5	5134	51340	1000	5.134	2.20
		5415	54150	1000	5.415	2.30
S6	1:6	3488	34880	9000	3.876	1.90
		3912	39120	9000	4.347	1.80
S7	1:7	2771	27710	1000	2.771	2.20
		2347	23470	1000	2.347	2.10
S8	1:8	1739	17390	1000	1.739	2.10
		2208	22080	1000	2.208	2.20

V. CONCLUSION

After all the experiments and investigation carried out on the blocks made from laterite and sharp sand which was stabilized by cement the following conclusions were made:

- Blocks made from laterite are lighter than blocks made by sharp sand as can be seen from the table.
- Laterite blocks with mix ratio 1:5 can comfortably be used to replace sandcrete blocks with mix ratio 1:6.
- Laterite blocks not stabilized by cement have strengths that are lower than the minimum required compressive strength.
- As the volume of laterite in the various mixes were increasing the compressive strength of the blocks reduced.

REFERENCES

[1]. Encyclopaedia Britannica (2016).

[2]. Ndububa E.E and Malgwi Y.I. 2016. Strength Improvement of Mud Houses Through Stabilization of the Lateritic Materials. The International Journal of Engineering and Science. Vol 5, Issue 9. pp 56 – 60.

[3]. Tanu H.M et al. 2020. A Study on Cement Stabilized Laterite Paver Blocks. International Journal of Scientific and Technology Research. Vol. 9, Issue 2. pp 404 – 409.

[4]. Komolafe O O and Osinubi K J. 2019. IOP Conf. Series: Materials Science and Engineering. pp 1 – 11.

[5]. Olutoge FA, Booth CA, Olawale SOA and Alebiosu OA. 2018. Lateritic cement- and lime-stabilised bricks and blocks for affordable housing. Proceedings of the Institution of Civil Engineers – Construction Materials 171(5): 195–202.