DETERMINATION OF COMPRESSIVE STRENGTH OF LATERITIC SANDCRETE CUBES

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ABSTRACT : This paper presents the determination of compressive strength of lateritic sandcrete cubes. In the course of the study we investigated the suitability of laterite as a partial replacement of sand, and specifically sought to determine whether lateritic sandcrete cubes would satisfy the minimum compressive strength requirement of Nigeria Industrial Standard for load bearing blocks for use in sandcrete blocks. This strength is 3.45N/mm². Potable water was used for this work and Dangote brand of Ordinary Portland Cement was used as binder. Various combinations of Laterite and sand were used. The least cement content of all the mixes is 10% of dry mass. Compressive cube strength and saturated surface dry (SSD) bulk density tests were conducted. Batching was by weight. Twenty-five mix ratios comprising of cement: laterite: sand were used. A total of 100 standard 150 mm x 150mm x 150mm lateritic sandcrete cubes were cast, cured for 28 days, weighed and crushed. The method of casting was the same as the method of casting traditional sandcrete blocks. The results show that the average SSD density of the lateritic sandcrete cubes are approximately 2334.97 Kg/m³, a value higher than the average value of 1983Kg/m³ conventional sandcrete blocks. Also, all mix ratios had compressive cube strengths higher than 3.45N/mm². Therefore, laterite could be used as part of fine aggregate for making sandcrete blocks. More so, since lateritic sandcrete cubes has a higher compressive strength than the minimum standard, it could be used as load bearing blocks in building construction. However, the cement content should not be less than 10% of dry mass.

Keywords: Saturated surface dry density, compressive strength, laterite, lateritic sandcrete cubes, load bearing blocks, partial replacement.

1INTRODUCTION

Sand has been the conventional fine aggregate in sandcrete blocks. The commonest types of sand used in this regard in various parts of Nigeria are river sand, erosion sand, and dune sand (desert sand). Due to scarcity and high cost of purchasing them, these sand types are not readily available in many parts of the country. Persons making sandcrete blocks in hinterland of Nigeria usually import sand from relatively distant places at high costs, and this increases the overall cost of making sandcrete blocks and of providing housing for the people. Thus, there is an increasing need to source alternative locally-available materials that could serve as suitable replacement (total or partly) to sand as fine aggregate in sandcrete block making. This study investigates the compressive strength of lateritic sandcrete cubes and the suitability of laterite as part of fine aggregate with sand. Laterite has the advantage of being readily available in most Nigerian communities. Besides being obtained intentionally in burrow pit excavations, it is also frequently obtained through various forms of excavations for substructure works, including excavations for foundations and septic tanks. However, unlike sand, laterite is a combination of different soil types, notably clay, sand, and silt. A good number of scholars have worked on laterite [1], [2], [3], [4] and established that, among other things, the presence of iron oxide accounts for its red colour. Thus, the suitability or otherwise of using laterite as part fine aggregate with sand in sandcrete would depend greatly on the proportion.

This study further seeks to determine whether laterite used as part fine aggregate with sand in sandcrete would satisfy the minimum compressive strength requirement of Nigerian Industrial Standard - NIS 87:2007 [5], which is between 2.5N/mm² to 3.45N/mm².

MATERIALS AND METHOD

Portable water, conforming to BS 3148, 1980[6], obtained from a public tap in Federal University of Technology, Owerri, Imo State, was used for this work. Dangote brand of ordinary Portland Cement (OPC) that confirms to BS 12(1978)[7] was used as binder. Laterite obtained from a burrow pit at Ihiagwa community, Owerri, was used as part of fine aggregate. An investigation into the engineering and geotechnical properties showed that the sample collected was laterite [8]. River sand from Otamiri River that is free from deleterious matters was also used as complementary fine aggregate. The laterite had low clay and silt content and was free from physical organic substances. The sieve analysis result for the laterite is as shown in table 1, with the grading curve shown in Fig. 1.

Batching was by weight. Twenty-five mix ratios comprising of cement: laterite: sand were used. Four standard cubes of 150mm x 150mm x 150mm lateritic sandcrete cubes were moulded for each mix, making a total of 100 cubes. Trial mix text was conducted to ascertain the required volume of water for the workability of the mix. The cube moulds were oiled to prevent adhesion of the material to the mould and also to aid easy de-moulding. Compaction was carried out using a standard tamping rod of 16mm. Each layer received 30 blows making a total of 90 blows per cube. After compaction, the cubes were de-moulded immediately and labeled according to their identification mark. The process was repeated for all the mix ratios. The various mix ratios are shown in table 2. The cubes were cured by sprinkling water on them twice a day for a period of twenty-eight (28) days. At the climax of the twenty-eighth day, the cubes were immersed in water for a period of 24 hours to be saturated with water. At the elapse of the time, the cubes were brought out and allowed to surface dry for another 30mins. Compressive cube strength and saturated surface dry (SSD) density tests were conducted in conformity with BS 1881: Part 115 (1986)[9]. The values of the saturated surface dry densities and the compressive cube strengths are tabulated in table 3 respectively.

RESULTS AND DISCUSSIONS

The results of the compressive cube strength and saturated surface dry (SSD) density tests for all the twenty-five mix ratios are presented in table 3 and fig.2. The result shows that the average SSD density of the lateritic sandcrete cubes is approximately 2334.97Kg/m³. This value exceeds the density of dense blocks made with dense aggregates as specified in [6], which include natural sand and crushed rocks and have densities of 1920 to 2080Kg/m³ and may be solid or hollow. Also, the compressive strength of the cubes increases with increase in the saturated surface dry density as shown in fig. 2. From table 3, the compressive cube strength ranges from 3.49N/mm² to 7.11N/mm², which are higher than the minimum compressive strength of sandcrete block by NIS 87:2007 ranging from 2.5N/mm² to 3.45N/mm².

From table 5, a comparison between the various mixes ratio with 14% cement content; it can be seen that the highest compressive strengths of the cubes are 7.11N/mm² and 6.11N/mm² with designation C2 and N5 respectively. These values are higher than that of the control mix without laterite with designation C8 having a strength of 5.42N/mm².

From table 6, a comparison between the mix ratios with 10% cement content, it can be seen that the mix ratios competing with the compressive strength of 5.91N/mm² with designation C10, includes 5.16N/mm² and 4.56N/mm² with designations N15 and N14 respectively.

From table 7, a comparison between mix ratios with 12% cement content; compressive strengths of almost equivalent values with 6.91N/mm² (designation C9-control mix without laterite) are 6.07N/mm², 5.73N/mm², and 5.56N/mm², with designations N10, N9 and C3 respectively.

Therefore, on the basis of the compressive strength, sandcrete with laterite as part of the fine aggregate could be suitable for construction as load bearing blocks provided a suitable mix ratios such as were used in this research. The laterite content and the corresponding compressive cube strength is tabulated in table 4 and the graph shown in fig 3, and it can be deduced that with increase in the content of laterite there is a corresponding decrease in the compressive strength of the cube but with lower laterite content, the compressive strength increases.

CONCLUSIONS

A study of compressive strength characteristics of laterite/sand cubes has been carried out. Generally, the compressive strength of sandcrete cubes decreases as the content of laterite increases.

From this study, the following conclusions can be drawn:

- The compressive strengths of the lateritic sandcrete cubes compared favourably with those of sandcrete blocks.
- Lateritic sandcrete cubes are more economical building materials for walling units than the sandcrete blocks
- Lateritic sandcrete cubes have densities that are higher than their sandcrete counterparts and they may likely provide more solid and durable walls in buildings.
- Compressive strength increases as the SSD density increases.

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FIGURES AND TABLES

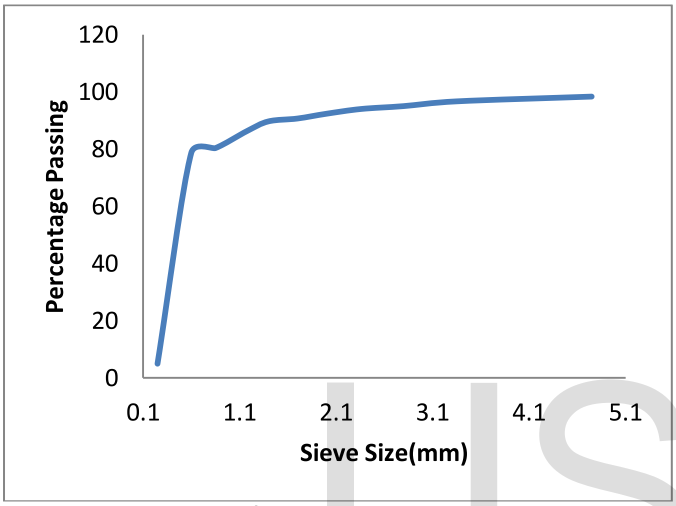

Fig. 1. Grading curve of laterite.

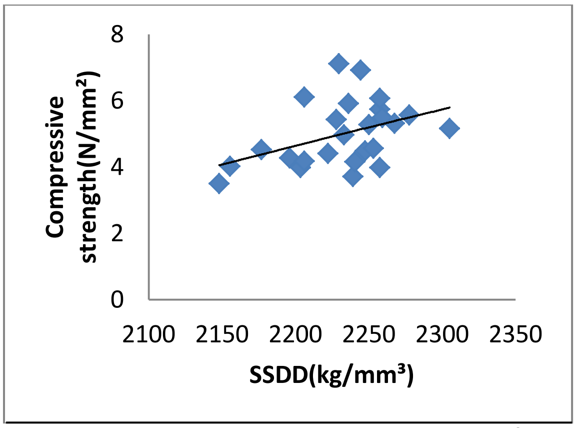

Fig 2. 28 days compressive strength and SSDD for lateritic sandcrete cubes

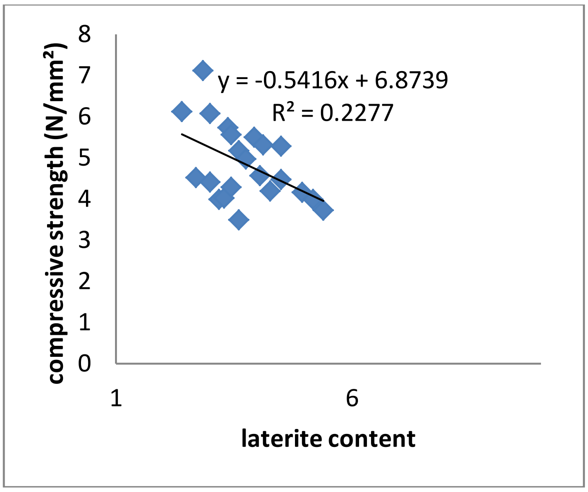

Fig 3. 28 days compressive strength and corresponding laterite contents

Table 1: Sieve analysis result of laterite

Sieve sizes(mm)	Weight of sieve(kg)	Weight of sample+ sieve(kg)	Weight of retained sample(kg)	Quantity passing(kg)	Cumulative retained	% cum retained	% cum passing
0	0.3	0.4	0.1	0	3	100	0
0.196	0.3	0.35	0.05	-0.05	2.9	96.67	3.33
0.25	0.35	2.56	2.21	-2.26	2.85	95	5
0.6	0.35	0.4	0.05	-2.31	0.64	21.33	78.67
0.85	0.3	0.48	0.18	-2.49	0.59	19.67	80.33
1.18	0.35	0.45	0.1	-2.59	0.41	13.67	86.33
1.4	0.35	0.38	0.03	-2.62	0.31	10.33	89.67
1.7	0.4	0.45	0.05	-2.67	0.28	9.33	90.67
2	0.4	0.45	0.05	-2.72	0.23	7.67	92.33
2.36	0.35	0.38	0.03	-2.75	0.18	6	94
2.8	0.4	0.45	0.05	-2.8	0.15	5	95
3.35	0.5	0.55	0.05	-2.85	0.1	3.33	96.67
4.75	0.35	0.4	0.05	-0.05	0.05	1.67	98.33
		total	3				

Table 2. Mix ratios

S/N	Cement	River sand	Laterite
N1	1	2.4	3.6
N2	1	2.7	3.3
N3	1	3	3
N4	1	3.3	2.7
N5	1	3.6	2.4
N6	1	3	4.5
N7	1	3.375	4.125
N8	1	3.75	3.75
N9	1	4.125	3.375
N10	1	4.4	3

N11	1	3.6	5.4
N12	1	4.05	4.95
N13	1	4.5	4.5
N14	1	4.95	4.05
N15	1	5.4	3.6
C1	1	2.55	3.45
C2	1	3.15	2.85
C3	1	3.3	3.45
C4	1	3.563	3.938
C5	1	4.313	3.188
C6	1	3.825	5.175
C7	1	4.725	4.275
C8	1	6	0
C9	1	7.5	0
C10	1	9	0

Table 3. Values of saturated surface dry density (SSDD) and compressive cube strength

	mass of cubes(Kg)					SSDD	Compressive forces(KN)					Cube strength
	1st	2nd	3rd	4th	Avg.	(Kg/m³)	1st	2nd	3rd	4th	Avg.	N/mm²
N1	7.3	7.05	7.3	7.35	7.25	2148.1481	74	82	78	80	78.5	3.49
N2	7.35	7.15	7.3	7.3	7.28	2155.5556	94	94	88	86	90.5	4.02
N3	7.45	7.6	7.4	7.55	7.50	2222.2222	106	90	98	102	99	4.40
N4	7.19	7.6	7.2	7.4	7.35	2177.037	92	114	98	102	101.5	4.51
N5	7.45	7.75	7.35	7.23	7.45	2205.9259	118	168	112	152	137.5	6.11
N6	7.6	7.58	7.55	7.65	7.60	2250.3704	102	134	122	116	118.5	5.27
N7	7.6	7.68	7.65	7.68	7.65	2267.4074	112	126	122	118	119.5	5.31
N8	7.55	7.55	7.5	7.55	7.54	2233.3333	122	98	102	124	111.5	4.96
N9	7.65	7.68	7.55	7.6	7.62	2257.7778	128	128	128	132	129	5.73
N10	7.58	7.65	7.6	7.65	7.62	2257.7778	136	136	136	138	136.5	6.07
N11	7.45	7.68	7.5	7.6	7.56	2239.2593	78	90	78	88	83.5	3.71
N12	7.6	7.4	7.6	7.65	7.56	2240.7407	104	78	104	88	93.5	4.16
N13	7.65	7.54	7.55	7.6	7.59	2247.4074	98	96	102	106	100.5	4.47
N14	7.54	7.65	7.55	7.68	7.61	2253.3333	96	98	104	112	102.5	4.56
N15	7.8	7.82	7.65	7.85	7.78	2305.1852	138	96	102	128	116	5.16
C1	7.32	7.45	7.4	7.48	7.41	2196.2963	74	94	112	104	96	4.27
C2	7.4	7.65	7.45	7.6	7.53	2229.6296	166	154	162	158	160	7.11
C3	7.71	7.65	7.7	7.68	7.69	2277.037	102	144	114	140	125	5.56
C4	7.65	7.6	7.6	7.65	7.63	2259.2593	128	120	120	126	123.5	5.49
C5	7.7	7.5	7.6	7.68	7.62	2257.7778	80	92	98	88	89.5	3.98
C6	7.35	7.55	7.4	7.45	7.44	2203.7037	98	60	98	102	89.5	3.98
C7	7.4	7.45	7.45	7.48	7.45	2205.9259	78	94	98	106	94	4.18
C8	7.45	7.6	7.48	7.55	7.52	2228.1481	120	120	122	126	122	5.42
C9	7.55	7.6	7.5	7.65	7.58	2244.4444	160	150	154	158	155.5	6.91
C10	7.52	7.62	7.5	7.55	7.55	2236.2963	132	126	138	136	133	5.91

Table 4. % laterite content and corresponding compressive strength

S/N	%Laterite	strength(N/mm²)

N1	51.4	3.49
N2	47.1	4.02
N3	42.9	4.40
N4	38.6	4.51
N5	34.3	6.11
N6	52.9	5.27
N7	48.5	5.31
N8	44.1	4.96
N9	39.7	5.73
N10	35.3	6.07
N11	54.0	3.71
N12	49.5	4.16
N13	45	4.47
N14	40.5	4.56
N15	36	5.16
C1	49.3	4.27
C2	49.3	7.11
C3	44.5	5.56
C4	46.3	5.49
C5	37.5	3.98
C6	51.8	3.98
C7	42.75	4.18
C8	0	5.42
C9	0	6.91
C10	0	5.91

Table 7: mix ratios with 12% cement content

S/N	N6	N7	N8	N9	N10	C4	C5	C3	C9
Cement	1	1	1	1	1	1	1	1	1
Sand	3	3.4	3.8	4.1	4.5	3.7	4.3	3.3	7.5
Laterite	4.5	4.1	3.8	3.4	3	3.9	3.2	3.5	0
Total	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
%cement	12	12	12	12	12	12	12	12	12
%sand	35	39	44	48	52	41	50	42	88
%laterite	53	48	44	39	35	46	37	44	0
strength (N/mm^2)	5.3	5.3	4.9	5.7	6.1	5.5	3.9	5.6	6.9

Table 5: mix ratios with 14% cement content

S/N	N1	N2	N3	N4	N5	C1	C2	C3
Cement	1	1	1	1	1	1	1	1
Sand	2.4	2.7	3	3.3	3.6	2.6	3.2	6
Laterite	3.6	3.3	3	2.7	2.4	3.5	2.9	0
Total	7	7	7	7	7	7	7	7
%cement	14	14	14	14	14	14	14	14
%sand	34	38	42	47	51	36	45	85
%laterite	51	47	42	38	34	49	40	0
strength (N/mm^2)	3.5	4	4.4	4.5	6.1	4.3	7.1	5.4

Table 6: mix ratios with 10% cement content

S/N	N11	N12	N13	N14	N15	C6	C7	C10
Cement	1	1	1	1	1	1	1	1
Sand	3.6	4.1	4.5	4.9	5.4	3.8	4.7	9
Laterite	5.4	4.9	4.5	4.1	3.6	5.2	4.3	0
Total	10	10	10	10	10	10	10	10
%cement	10	10	10	10	10	10	10	10
%sand	36	41	45	49	54	38	47	90
%laterite	54	49	45	41	36	52	43	0
strength (N/mm^2)	3.7	4.2	4.5	4.6	5.2	3.9	4.2	5.9