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Production and Testing of Lateritic Interlocking Blocks

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Abstract: The production and testing of lateritic interlocking blocks were examined. The experiments involved the production of 250 × 130 × 220 mm^3 interlocking blocks with laterite samples obtained from Aroje (Ogbomoso North L.G), Olomi (Ogbomoso South L.G), Idioro (Surulere L.G) and Tewure (Orire L.G) using a locally fabricated manual steel mould and a 4.5 kg rammer. The blocks were tested in the laboratory to determine their compressive strength, water absorption and resistance to abrasion. The results indicated that all of the stabilised blocks satisfied the minimum 28 day wet compressive strength of 1.0 Nmm^{-2} recommended by the Nigeria Building and Road Research Institute. The minimum seven day dry compressive strength for 5% cement stabilised blocks of not less than 1.60 Nmm^{-2}, as recommended in the National Building Code, was not satisfied by all of the blocks. However, with 10% cement stabilisation, blocks from Olomi and Idioro laterites satisfied the minimum seven day strength with values of 2.13 Nmm^{-2} and 1.62 Nmm^{-2}, respectively. Only laterites from Olomi and Idioro that met the minimum seven day requirements were concluded to be suitable for the production of interlocking blocks in southwestern Nigeria.

Keywords: Laterite, Interlocking block, Ordinary Portland cement, Compressive strength, Durability

INTRODUCTION

Housing is universally acknowledged as one of the basic needs of humans, and its ownership is one of the most cherished cultural acquisitions. Unfortunately, because of the large population of poor citizens, many Nigerians are unable to afford houses of their own. The ownership of houses has largely eluded them because of the high costs of building materials. Thus, it has become necessary to find ways of cutting building construction costs. The use of locally sourced materials, such as laterite soil, is a possible solution.

Laterite is a red tropical soil that is rich in iron oxide and is usually derived from rock weathering under strongly oxidising and leaching conditions. It forms in tropical and sub-tropical regions where the climate is humid (Mahalinga-Iyer and Williams, 1997). Laterite is very abundant in Ceylon, India, Burma, Central Africa, West Africa and Central America (Encyclopedia Britannica, 2001). It has been found to be less permeable when stabilised with palm oil, ordinary Portland cement (OPC) or clay from termite heaps (Encyclopedia Encarta, 2004). Because of the large deposits of laterite in Nigeria and most neighbouring African countries, the material is easily acquired and inexpensive. The potential of laterite is not presently being maximised in the area of brick production for building purposes.

The most common walling materials are conventional sandcrete blocks and fired clay bricks. The high cost of sandcrete blocks coupled with the low strength properties of commercially available blocks necessitates the development of an alternative brick material. In comparison to the use of sandcrete blocks, the use

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laterite for brick production is economical because little cement is required. Also, when compared with fired clay bricks, the production of laterite bricks does not involve the firing process.

Several researchers have reported that cement-stabilised laterite can be used in building and road construction (Folagbade, 1998; Agbede and Manasseh, 2008; Raheem et al., 2010). Literature is scarce, however, on the use of laterite interlocking blocks. A previous study by the Nigerian Building and Road Research Institute (NBRRI) involved the production of laterite bricks that were used for the construction of a bungalow (Madedor, 1992). In that study, the NBRRI proposed the following minimum specifications as requirements for laterite bricks: a bulk density of 1810 kg/m^3, a water absorption of 12.5%, a compressive strength of 1.65 N/mm^2 and a durability of 6.9% with a maximum cement content fixed at 5%. The present study considered the production of laterite interlocking blocks.

Apart from the cost of materials used in making blocks for walling units, the cost of cement mortar used in bonding the blocks together also contributes to the exorbitant cost of building works. The technique of building with interlocking blocks eliminates the need for mortar in walling units and consequently reduces building costs. This study evaluated the characteristics of interlocking blocks produced with laterite soils obtained from four different locations within Ogbomosoland in Nigeria.

MATERIALS AND METHOD

Laterite samples were obtained from four locations within Ogbomosoland: Aroje (Ogbomoso North L.G), Olomi (Ogbomoso South L.G), Idioro (Surulere L.G) and Tewure (Orire L.G). These samples were stabilised with ordinary Portland cement using 0%, 5%, 10% and 15% by weight cement content, with 0% stabilisation representing the control. The laterite samples were then used to produce interlocking blocks, which were tested for strength and durability. All the processes were performed with reference to the International Labour Organisation manual (1987), Nigeria Building and Road Research Institute (2006) and National Building Code (2006) specifications.

Preparation of Laterite Samples

The laterite samples were air-dried for seven days in a cool, dry place. Air drying was necessary to enhance grinding and sieving of the laterite. After drying, grinding was performed using a punner and a hammer to break the lumps present in the soil. Sieving was then performed to remove oversized materials from the laterite samples using a wire mesh screen with an aperture diameter of approximately 6 mm, as recommended by Oshodi (2004). Fine materials that passed through the sieve were collected for use, whereas those retained were discarded.

Production of Lateritic Interlocking Blocks

The interlocking blocks were produced using a locally fabricated steel mould that measured 250 × 130 × 220 mm^3 (see Figure 1). The production process comprises the batching, mixing, casting and compaction of the blocks.

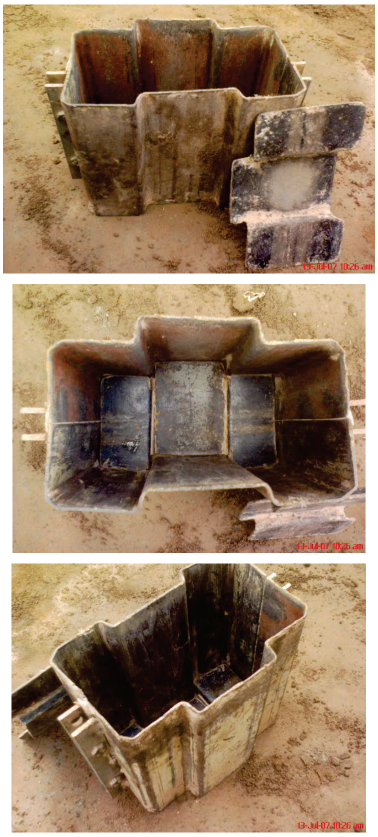

Figure 1. Locally Fabricated Steel Mould

The materials used for the production of lateritic interlocking blocks were measured by weight in accordance with the predetermined percentages of stabilisation (5%, 10% and 15%) and the optimum moisture contents determined in the field. Table 1 shows the mass of each material used for the varying percentages of stabilisation considered.

Table 1. Batching Information for Laterite Samples Used

A. Aroje (Ogbomoso North L.G)

Date	**% of Stabilisation**	**Laterite (kg)**	**Cement (kg)**	**Water (kg)**	**w/c**
14/06/07	0	335.30	–	34.20	–
18/06/07	5	289.39	14.47	29.52	2.04
06/07/07	10	305.54	30.55	62.34	2.04
11/07/07	15	271.64	40.75	83.12	2.04

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Table 1. (*continued*)

B. Olomi (Ogbomoso South L.G)

Date	% of Stabilisation	Laterite (kg)	Cement (kg)	Water (kg)	w/c
03/07/07	0	120.86	–	17.46	–
04/07/07	5	310.76	11.43	28.00	2.45
05/07/07	10	271.53	27.15	66.52	2.45
13/07/07	15	235.90	35.38	86.70	2.45

C. Idioro (Surulere L.G)

Date	% of Stabilisation	Laterite (kg)	Cement (kg)	Water (kg)	w/c
16/07/07	0	282.20	–	24.38	–
08/07/07	5	235.83	11.74	27.00	2.30
17/07/07	10	312.43	34.72	79.86	2.30
18/07/07	15	353.89	53.07	122.08	2.30

D. Tewure (Orire L.G)

Date	% of Stabilisation	Laterite (kg)	Cement (kg)	Water (kg)	w/c
15/06/07	0	306.40	–	80.40	–
10/07/07	5	353.39	50.52	97.00	1.92
19/07/07	10	354.37	55.13	105.84	1.92
20/07/07	15	353.67	53.04	101.84	1.92

The mixing was performed on an impermeable surface made free (by sweeping and brushing or scraping) from all harmful materials that could alter the properties of the mix. The measured laterite sample was spread using a shovel to a reasonably large surface area. Cement was then spread evenly on the laterite and mixed thoroughly with the shovel. The dry mixture was spread again to receive water, which was added gradually while mixing until the optimum moisture content of the mixture was attained. The optimum moisture content (OMC) of the mixture was determined by progressively wetting the soil, collecting handfuls of the soil, compressing it firmly in the fist, then allowing it to drop on a hard and flat surface from a height of approximately 1.10 m. When the soil breaks into four or five parts, the water content is considered correct (National Building Code, 2006).

After the steel mould was rid of all impurities, it was coupled together and oiled to enhance the demoulding of the blocks. The wet mixture was filled into the mould in 3 layers, with each layer being compacted with 35 blows of 4.5 kg rammer on a level and rigid platform. The excess mixture was scraped off, and the mould was levelled using a straight edge. The mould and its contents were left for two hours before the removal of the mould. Identification marks were inscribed on the blocks to allow easy referencing.

The blocks were first allowed to air dry for 24 hours under a shade constructed from a polythene sheet. Thereafter, water was sprinkled on the blocks in the morning and evening, and the blocks were covered with a polythene sheet for one week to continue the curing process and prevent rapid drying of the blocks, which could lead to shrinkage cracking. The blocks were later stacked in rows and columns with a maximum of five blocks in a column until they were ready for strength and durability tests (see Figure 2).

Figure 2. Stacking of Lateritic Interlocking Blocks

Testing of Lateritic Interlocking Blocks

Durability, water absorption and compressive strength tests were performed on the blocks. The durability of the blocks was determined through abrasion testing. After the interlocking blocks attained the specified ages, two blocks were selected at random and weighed in the laboratory; their weight was recorded. The blocks were placed on a smooth and firm surface, and then all the surfaces were wire-brushed in a back-and-forth motion 50 times, where one back and forth motion was considered a single stroke. After being brushed, the blocks were weighed again to determine the amount of material or particles abraded. This procedure was repeated for all the blocks produced with various cement contents and for blocks of various ages.

For the water absorption tests, two blocks were randomly selected from each group of the specified age and were weighed on a balance. These blocks were then immersed completely in water for 24 hours, after which they were removed and weighed again. The percentages of water absorbed by the blocks were estimated as follows:

$$Wa = \frac{Ws - Wd}{Wd} \times 100 \qquad (1)$$

where:

Wa = percentage moisture absorption
Ws = weight of soaked block
Wd = weight of dry block

Compressive strength tests were performed to determine the load-bearing capacities of the blocks. The wet and dry compressive strengths were determined. For the dry compressive strength tests, the blocks aged three, seven, 21 and 28 days were transported from the curing or stacking area to the laboratory two hours prior to the test to normalise the temperature and to ensure that the block was relatively dry. The weight of each block was measured before the block was placed onto the compression testing machine (Model 50-C34A2, Serial no. 0294910, CONTROLS, Italy) such that the top and bottom, as moulded, lied horizontally on a flat metal plate; the recesses were filled with a metal plate of the exact size to prevent sheaving of the block during testing. The block was then crushed, and the corresponding failure load was recorded. The crushing force was divided by the sectional area of the block to arrive at the compressive strength.

To measure the wet compressive strength, the blocks selected for testing were immersed completely in water for 24 hours, after which they were removed, weighed and crushed as suggested in the International Labour Organisation and NBRRI specifications. This test was performed to determine the strength of the blocks under heavy rainfall.

RESULTS AND DISCUSSION

Durability

Figure 3 shows the results of the abrasion tests. Based on the results in the figure, 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), and the blocks made from Aroje laterite had the highest value of abraded material (0.34%). These results indicate that cement stabilisation is required to enhance the durability of the blocks. The blocks produced from Idioro laterite had lower percentages of abraded material, which is an indication of higher durability.

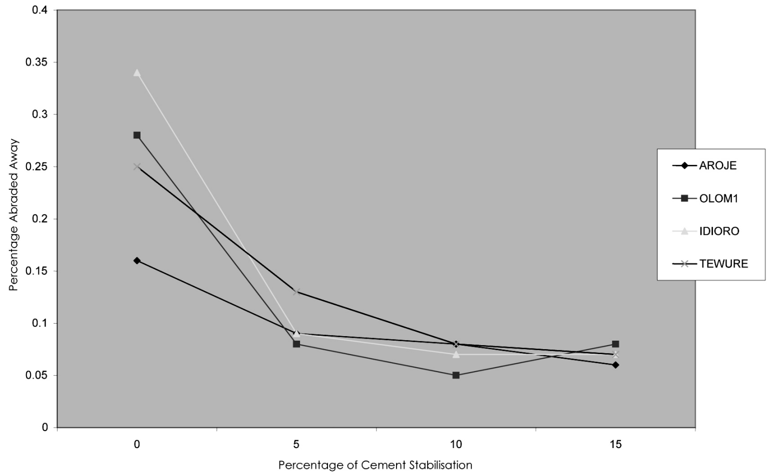

Figure 3. Result of Abrasive Test for Laterite Interlocking Blocks

Water Absorption

The results of the water absorption tests are presented in Table 2. In general, the results indicate that water absorption decreases with increased percentages of stabilisation. This result was expected because the cement binds the laterite particles together and thereby reduces the sizes of the pores through which water could flow into the blocks. No measurements were obtained for the control (0% stabilisation) because the control blocks dissolved in the surrounding water. The maximum water absorption of 12% recommended in the Nigerian Industrial Standard (2004) was satisfied by the blocks produced with laterite from the Aroje, Olomi and Idioro deposits. Interlocking blocks produced with Idioro laterite exhibited the lowest percentages of water absorbed: 7.62%, 5.23% and 5.01% for blocks with 5%, 10% and 15% cement stabilisation, respectively.

Table 2. Result of Water Absorption for Interlocking Blocks Produced With Laterite

A. Aroje (Ogbomoso North L.G)

Cement Stabilisation (%)	Dry Mass (kg)	Wet Mass (kg)	Water Absorbed (%)	Average Water Absorbed (%)
0	–	–	–	–
	–	–	–	
5	13.806	15.234	10.34	10.15
	13.540	14.892	9.97	
10	14.200	15.124	6.43	7.09
	14.440	15.560	7.76	
15	14.050	14.860	5.76	5.35
	13.950	14.640	4.95	

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Table 2. (*continued*)

B. Olomi (Ogbomoso South L.G)

Cement Stabilisation (%)	Dry Mass (kg)	Wet Mass (kg)	Water Absorbed (%)	Average Water Absorbed (%)
0	–	–	–	–
	–	–	–	
5	13.840	15.354	10.90	10.95
	13.650	15.157	11.00	
10	13.824	15.141	9.50	9.48
	13.950	15.270	9.46	
15	13.064	14.318	9.60	9.17
	13.210	14.430	8.74	

C. Idioro (Surulere L.G)

Cement Stabilisation (%)	Dry Mass (kg)	Wet Mass (kg)	Water Absorbed (%)	Average Water Absorbed (%)
0	–	–	–	–
	–	–	–	
5	14.440	15.530	7.55	7.62
	14.530	15.648	7.69	
10	14.120	14.842	5.11	5.23
	14.333	15.098	5.34	
15	14.092	14.987	6.35	6.07
	13.871	14.675	5.79	

D. Tewure (Orire L.G)

Cement Stabilisation (%)	Dry Mass (kg)	Wet Mass (kg)	Water Absorbed (%)	Average Water Absorbed (%)
0	–	–	–	–
	–	–	–	
5	12.399	14.013	13.02	12.99
	12.540	14.167	12.97	
10	12.602	14.254	13.11	12.60
	12.347	13.840	12.09	
15	13.407	14.570	8.67	8.35
	13.609	14.701	8.02	

Compressive Strength

The results of the dry and wet compressive strength tests are presented in Tables 3 to 6. In general, the compressive strength of the blocks increased as the age and percentage stabilisation increased.

For the blocks produced with laterite from Aroje, the dry and wet compressive strengths at 28 days varied from 1.45 N/mm^2 to 2.49 N/mm^2 and from 0.45 N/mm^2 to 2.01 N/mm^2 as the percentage stabilisation was increased from 0% to 15%, respectively. The same pattern was observed for the Idioro laterite, the strengths of which varied from 1.41 N/mm^2 to 2.74 N/mm^2 and from 0.32 N/mm^2 to 2.04 N/mm^2 at percent stabilisations of 0% and 15%, respectively.

Table 3. Density and Compressive Strength of Interlocking Blocks Produced With Laterite from Aroje

The Control (0% Stabilisation)

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm^2)	Average Wet Compressive Strength (N/mm^2)
3	14.114	1782	12.5	–	11.5	–	0.37	–
	14.320	1808	10.5	–				
7	14.009	1769	30.0	–	31.5	–	1.01	–
	13.840	1747	33.0	–				
14	12.364	1561	43.0	–	44.0	–	1.42	–
	12.850	1622	45.0	–				
28	13.538	1709	46.0	15.0	45.0	13.5	1.45	0.43
	12.560	1585	44.0	12.0				

5% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm^2)	Average Wet Compressive Strength (N/mm^2)
3	14.320	1808	17.5	15.0	18.25	15.00	0.58	0.48
	14.570	1840	19.0	15.0				
7	14.027	1771	43.0	22.5	43.00	21.25	1.38	0.68
	14.010	1769	43.0	20.0				
14	13.540	1709	46.0	30.0	47.00	32.50	1.51	1.05
	13.890	1754	48.0	35.0				
28	13.860	1743	50.0	33.0	52.50	35.50	1.69	1.14
	13.440	1697	55.0	38.0				

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Table 3. (*continued*)

10% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm²)	Average Wet Compressive Strength (N/mm²)
3	14.820	1871	17.5	15.0	18.75	17.5	0.60	0.56
	14.550	1837	20.0	20.0				
7	14.438	1823	45.0	30.0	47.50	31.5	1.53	1.01
	14.570	1839	50.0	33.0				
14	14.460	1826	55.0	40.0	52.50	37.5	1.69	1.21
	14.770	1865	50.0	35.0				
28	14.001	1768	75.0	60.0	75.00	62.5	2.42	2.01
	13.980	1765	75.0	65.0				

15% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm²)	Average Wet Compressive Strength (N/mm²)
3	14.170	1789	35.0	30	36.50	27.5	1.17	0.88
	14.240	1798	38.0	25				
7	13.942	1760	47.5	35	48.75	34.0	1.57	1.09
	13.680	1727	50.0	33				
14	13.913	1756	60.0	45	57.50	42.5	1.85	1.36
	13.917	1757	55.0	40				
28	13.503	1705	75.0	60	77.50	62.5	2.49	2.01
	13.330	1683	80.0	65				

Table 4. Density and Compressive Strength of Interlocking Blocks Produced With Laterite From Olomi

The Control (0% Stabilisation)

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm²)	Average Wet Compressive Strength (N/mm²)
3	14.509	1832	15.0	–	17.50	–	0.56	–
	14.350	1812	20.0	–				
7	14.110	1782	22.5	–	23.75	–	0.76	–
	14.240	1798	25.0	–				
14	13.992	1766	35.0	–	34.0	–	1.09	–
	13.740	1735	33.0	–				
28	13.792	1741	45.0	–	45.0	–	1.45	–
	13.840	1747	45.0	–				

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Table 4. (*continued*)

5% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm²)	Average Wet Compressive Strength (N/mm²)
3	14.616	1845	27.5	15	25.75	15.0	0.83	0.48
	14.754	1863	24.0	15				
7	14.236	1797	46.0	25	45.50	27.5	1.46	0.88
	14.440	1823	45.0	30				
14	14.630	1847	46.0	30	47.50	32.5	1.53	1.05
	14.570	1839	49.0	35				
28	13.988	1767	50.0	35	55.00	37.5	1.77	1.21
	14.110	1782	60.0	40				

10% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm²)	Average Wet Compressive Strength (N/mm²)
3	14.42	1820	37.0	22.5	36.00	25.75	1.04	0.83
	13.99	1766	35.0	29.0				
7	14.57	1839	65.0	30.0	66.00	32.50	2.13	1.05
	14.23	1797	67.0	35.0				
14	14.575	1840	67.5	40.0	68.75	40.00	2.21	1.28
	14.25	1799	70.0	40.0				
28	14.148	1786	75.0	42.0	77.50	44.50	2.49	1.43
	13.84	1747	80.0	47.0				

15% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm²)	Average Wet Compressive Strength (N/mm²)
3	14.144	1786	35.5	32.5	33.0	31.25	1.06	1.01
	14.230	1797	30.5	30.0				
7	13.910	1756	65.0	42.5	62.5	43.75	2.01	1.41
	13.570	1713	60.0	45.0				
14	13.920	1757	70.0	45.0	67.5	47.50	2.17	1.53
	13.560	1712	65.0	50.0				
28	13.320	1682	78.0	50.0	80.0	52.50	2.57	1.69
	13.465	1700	82.0	55.0				

Table 5. Density and Compressive Strength of Interlocking Blocks Produced With Laterite From Idioro

The Control (0% Stabilisation)

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm²)	Average Wet Compressive Strength (N/mm²)
3	14.440	1823	14.0	–	14.50	–	0.46	–
	14.620	1846	15.0	–				
7	14.358	1813	21.5	–	20.75	–	0.66	–
	14.420	1821	20.0	–				
14	14.146	1786	32.5	–	33.75	–	1.09	–
	14.235	1797	35.0	–				
28	13.205	1667	42.5	10.0	43.75	10.00	1.41	0.32
	13.570	1713	45.0	10.0				

5% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm²)	Average Wet Compressive Strength (N/mm²)
3	15.588	1964	28.5	21.5	29.25	20.75	0.94	0.66
	15.373	1941	30.0	20.0				
7	15.314	1934	35.5	32.5	35.25	31.25	1.14	1.01
	15.472	1954	35.0	30.0				
14	15.396	1944	56.5	40.0	55.75	42.50	1.79	1.36
	15.271	1928	55.0	45.0				
28	14.492	1829	70.0	55.0	70.00	52.50	2.25	1.69
	14.773	1865	70.0	50.0				

10% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm²)	Average Wet Compressive Strength (N/mm²)
3	15.114	1908	28.5	25.0	30.75	28.75	0.99	0.93
	15.235	1924	33.0	32.5				
7	14.908	1882	46.0	35.0	45.50	37.50	1.46	1.25
	15.111	1908	45.0	40.0				
14	14.740	1861	53.0	41.0	51.50	43.00	1.66	1.38
	14.983	1892	50.0	45.0				
28	14.360	1813	85.0	67.5	82.50	66.25	2.65	2.13
	14.238	1797	80.0	65.0				

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Table 5. (*continued*)

15% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm²)	Average Wet Compressive Strength (N/mm²)
3	14.118	1783	46	40	45.5	40.0	1.46	1.28
	14.376	1815	45	40				
7	14.416	1820	50	45	52.5	43.5	1.69	1.40
	14.109	1781	55	42				
14	14.070	1776	70	55	70.5	55.0	2.26	1.77
	14.115	1782	71	55				
28	13.567	1713	85	62	85.0	63.5	2.74	2.04
	13.593	1716	85	65				

Lateritic interlocking blocks from Olomi and Tewure showed similar characteristics: their 28th-day dry compressive strengths varied from 1.45 N/mm² to 2.57 N/mm² and from 1.24 N/mm² to 2.33 N/mm² as the percentage stabilisation was increased from 0% to 15%, respectively. The wet compressive strength for the controls could not be determined because the blocks dissolved in water to a considerable extent during the 24 hours of immersion prior to the test. However, their wet strengths varied from 1.21 N/mm² to 1.69 N/mm² and from 1.45 N/mm² to 1.85 N/mm² as the percentage stabilisation increased from 5% to 15%, respectively. These results further reinforced the need for the stabilisation of the blocks.

All the stabilised blocks satisfied the minimum 28 day wet compressive strength of 1.0 N/mm² recommended by the Nigeria Building and Road Research Institute (NBRRI, 2006). However, only unstabilised blocks produced from Aroje and Idioro laterite met the 28 day wet compressive strength of between 0.2 N/mm² and 0.6 N/mm² recommended in the National Building Code (2006).

Table 6. Density and Compressive Strength of Interlocking Blocks Produced With Laterite From Tewure

The Control (0% Stabilisation)

Age (Day)	Dry mass (kg)	Dry density (kg/m3)	Dry crushing force (kN)	Wet crushing force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive strength (N/mm²)	Average Dry Compressive strength (N/mm²)
3	13.970	1764	7.5	–	9.00	–	0.290	–
	13.577	1714	10.5	–				
7	13.884	1753	17.5	–	16.25	–	0.520	–
	13.420	1694	15.0	–				
14	12.890	1627	25.0	–	27.50	–	0.885	–
	13.011	1643	30.0	–				
28	12.317	1555	37.0	–	38.50	–	1.235	–
	12.573	1587	40.0	–				

(*continued on next page*)

Table 6. (*continued*)

5% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm^2)	Average Wet Compressive Strength (N/mm^2)
3	14.260	1801	32.0	21.5	28.50	20.75	0.92	0.66
	14.314	1807	25.0	20.0				
7	13.735	1734	32.5	23.0	31.25	24.00	1.00	0.77
	13.890	1754	30.0	25.0				
14	12.915	1631	36.0	34.0	35.50	34.50	1.15	1.11
	12.990	1640	35.0	35.0				
28	12.979	1638	45.0	45.0	47.50	45.00.	1.53	1.45
	12.583	1588	50.0	45.0				

10% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm^2)	Average Wet Compressive Strength (N/mm^2)
3	13.770	1738	33.0	20	31.50	22.5	1.01	0.73
	13.477	1702	30.0	25				
7	14.012	1769	35.5	30	37.75	31.0	1.21	0.99
	13.761	1737	40.0	32				
14	12.982	1639	37.5	34	38.75	35.5	1.25	1.14
	13.225	1669	40.0	37				
28	13.293	1678	50.0	45	52.50	47.5	1.69	1.53
	12.660	1598	55.0	50				

15% Stabilisation

Age (Day)	Dry Mass (kg)	Dry Density (kg/m3)	Dry Crushing Force (kN)	Wet Crushing Force (kN)	Average Dry Crushing Force (kN)	Average Wet Crushing Force (kN)	Average Dry Compressive Strength (N/mm^2)	Average Wet Compressive Strength (N/mm^2)
3	14.115	1782	30	25.0	32.5	22.50	1.05	0.73
	14.220	1795	35	20.0				
7	14.310	1807	46	37.5	43.0	33.75	1.38	1.08
	13.980	1765	40	30.0				
14	14.110	1782	64	45.0	64.5	45.00	2.07	1.45
	14.225	1796	65	45.0				
28	13.892	1754	70	55.0	72.5	57.50	2.33	1.85
	13.773	1739	75	60.0				

The minimum seven day dry compressive strength for 5% cement stabilised blocks of not less than 1.60 N/mm^2, as recommended in the National Building Code (2006), was not satisfied by all the blocks. However, with 10% cement stabilisation, the blocks from Olomi and Idioro laterites met the minimum 7 day strength recommendation with values of 2.13 N/mm^2 and 1.62 N/mm^2, respectively, which could be attributed to the fact that laterite from these areas contains less fine material and more gravel and is less permeable, as reported by Raheem et al. (2010). The 28 day dry compressive strength of manually produced blocks with 5% cement stabilisation of not less than 2.0 N/mm^2, as recommended by the NBRRI (2006), was satisfied only by the blocks produced from Idioro laterite. All the blocks with greater than 5% cement stabilisation satisfied the minimum 28 day dry compressive strength, except those made from Tewure laterite, which exhibited a value of 1.69 N/mm^2. Because most of the lateritic interlocking blocks with 5% cement stabilisation do not satisfy the minimum requirements specified in the operating codes, 10% stabilisation is recommended. The additional 5% cement content compared to that used by Madedor (1992) is compensated by the non-usage of mortar in laying the interlocking blocks.

As evident from the results in Tables 3 to 6, more than 70% of the compressive strength at the 28th day had been developed by the 14th day of casting for most of the laterite interlocking blocks, which indicates that the blocks are ready for use after 14 days of curing.

The dry density of the unstabilised blocks varied from 1555 kg/m^3 to 1846 kg/m^3, whereas that of the stabilised blocks ranged from 1588 kg/m^3 to 1964 kg/m^3. These values are similar to those obtained by Madedor (1992). Furthermore, the results indicate that the stabilised blocks are denser than the unstabilised blocks.

CONCLUSION

Based on the findings in this study, the following conclusions were drawn:

1. Ten percent cement stabilisation is recommended for lateritic interlocking blocks produced from the study area to meet the minimum standards stated in the available codes.
2. Only laterite from Olomi and Idioro, which met the minimum seven day requirements, is suitable for the production of interlocking blocks in this area.
3. The interlocking blocks should be cured for a minimum of 14 days before being used in buildings.

REFERENCES

Agbede, I.O. and Manasseh, J. (2008). Use of cement: Sand admixture in laterite brick production for low cost housing. *Leonardo Electronic Journal of Practices and Technologies*, 12 (January–June): 163–174.

Folagbade, S.O. (1998). Charateristics of cement stabilised sandy: Lateritic hollow blocks. *Journal of Environmental Design and Management*, 1(1&2): 67–74.

International Labour Organisation. (1987). *Small-scale Manufacture of Stabilised Soil Blocks*. Technical Memorandum No.12. Geneva: International Labour Office.

Madedor, A. O. (1992). The impact of building materials research on low cost housing development in Nigeria. *Engineering Focus*, 4(2) April–June: 37–41.

Mahalinga-Iyer, U. and Williams, D.J. (1997). Properties and performance of lateritic soil in road pavements. *Engineering Geology*, 46(2): 71–80.

Encyclopedia Britannica. (2001). *Laterite*. [Accessed on 14 February 2010].

Encyclopedia Encarta. (2004). *Laterite*. [Accessed on 14 February 2010].

National Building Code. (2006). *Building Regulations*. Ohio: Lexis Nexis Butterworths.

NBRRI (Nigeria Building and Road Research Institute). (2006). NBRRI interlocking block making machine. *NBRRI Newsletter*, 1(1):15–17.

Nigerian Industrial Standard. (2004). *Standard for Sandcrete Blocks*. ICS 91.100.20. Abuja, Nigeria: Nigerian Industrial Standard.

Oshodi, O.R. (2004). Techniques of producing and dry stacking interlocking blocks. Paper presented at the *Nigerian Building and Road Research Institute (NBRRI) Workshop on Local Building Materials*, Ota, Ogun State, Nigeria.

Raheem, A.A., Osuolale, O.M., Onifade, I. and Abubakar, Z. (2010). Charaterisation of Laterite in Ogbomoso Oyo State, Nigeria. *Journal of Engineering Research*, 15(2): 71–79.