Nigerian Research Journal of Engineering and Environmental Sciences
Journal homepage: www.rjees.com

Original Research Article

Effect of Partial Replacement of Laterite with Sand on some Mechanical Properties of Building Blocks

***Okere, C.E.**

Department of Civil Engineering, School of Engineering and Engineering Technology, Federal University of Technology, PMB 1526, Owerri, Nigeria.
*chinenyeeokere@gmail.com

ARTICLE INFORMATION

Article history:
Received 27 Sep, 2020
Revised 14 Oct, 2020
Accepted 14 Oct, 2020
Available online 30 Dec, 2020

Keywords:
Laterite blocks
Water absorption
Flexural strength
Compressive strength
Shear strength
Split tensile strength
Partial replacement

ABSTRACT

A good number of structural failures cannot be unconnected to the quality of blocks used as walling materials (which provide lateral stability) in the construction of these structures. Some mechanical properties which have been ignored to an extent with regards to block moulding technology were considered in this work. Blocks were produced with readily sourced and affordable laterite (in some locations) and partially replaced with river sand to reduce the effect of rising cost of river sand and to take advantage of the various desirable properties of laterite. The effect of this replacement (10% - 40%) was considered on the mechanical properties as well as the water absorption rate and the results show that inclusion of sand in the mix improved the mechanical properties but reduced the durability assessed by the water absorption rate.

1. INTRODUCTION

Building blocks are primarily used as building materials in the construction of walls. They can also be referred to as masonry units. Block moulding technology, which is a major theme in Civil Engineering, is becoming the backbone of infrastructural development of every country (Okere and Onwuka, 2016). In West Africa, the construction of most housing units depends largely on these building blocks which ultimately affect the total cost of construction. Building materials constitute about 60 to 75% of total cost of construction (Adegun and Adedeji, 2017).

Different varieties of blocks exist, depending on the raw materials adopted in their production. The raw materials range from conventional ones like cement, water, fine aggregates (river sand, clay, laterite), coarse aggregates (gravel), to unconventional ones like granulated coal, volcanic cinders, expanded clay, shale or slate, quarry dust, admixtures, etc. The choice of material depends largely on preference, availability and affordability of the material, desired strength, weight of the finished block and even aesthetics.

The production method includes three major steps namely, mixing, molding and curing. The manufacturing process involves compaction of newly mixed constituent materials in a mould followed immediately by extrusion of the pressed block so that the mould can be used repeatedly. The finished blocks are required to be self-supporting and able to withstand any movement and vibration from the moment they are extruded. The final stage of block production is curing just as it is in concrete production.

Laterite is readily obtainable and affordable in most regions of West Africa. Similarly, river sand is available in most riverine areas although the cost of dredging can skyrocket its final cost. The use of laterite in block production is proposed in areas where it is in abundance. Literature has identified some properties and benefits of laterite that make it a desirable material. These include thermal insulating and water-resistant properties, relatively low degree of porosity, natural beauty and even resistance to termites, bacteria and fungi (Komolafe, 1986; Boeck et al., 2000; Adam, 2001; Agbede and Manasseh, 2008; Aguwa, 2010; Okere, 2017).

Nigerian Building and Road Research Institute (NBRRI) proposed a compressive strength value of 1.65 N/mm^2 for laterite blocks (Madedor, 1992). It is interesting to note that the author has already ascertained that laterite blocks could be produced with 10% cement content to yield a compressive strength value of 2.1 N/mm^2. This is greater than the recommended value by NBRRI. Moreover, this value can compete favourably with the recommended value of Nigerian Industrial Standard (NIS) for hand- compacted sandcrete blocks which is 2 N/mm^2 (Okere, 2017).

Strength or mechanical properties are physical properties a material exhibits upon the application of forces. Blocks and concrete belong to the same household and both are expected to exhibit similar characteristics. The mechanical properties of concrete and by extension, blocks include compressive strength, shear strength, transverse strength, tensile strength, flexural strength. Strength of concrete or block is commonly considered its most valuable property, though in many practical cases, other characteristics such as durability and impermeability, may in fact be more important (Neville, 1981). Nevertheless, strength usually gives an overall picture of the quality of blocks because strength is directly related to the structure of the hardened cement paste. The strength/mechanical properties of these blocks are of much importance. Recall that blocks are used as walling units in construction of civil infrastructures. Walls which are load bearing act as form of bracing to structural frames and also provide lateral stability to structures. Some structural failures can be traced to poor/low quality blocks. Blocks fail by shearing.

Durability is the ability of the block to withstand the conditions for which it has been designed, without deterioration, over a period of years. Blocks and concrete should be dense, reasonably water tight (or less permeable), able to resist changes in temperature as well as wear and tear from weathering. Penetration of blocks by materials in solution may adversely affect its durability. This penetration depends on the permeability of the blocks. Permeability can be in form of water permeability, air and vapour permeability. The water absorption rate of laterite block can be used as a yardstick for measuring its durability as could be seen from the work of Okere and Onwuka (2016).

For blocks produced in Nigeria, apart from the compressive strength of blocks, very little is known about its other structural characteristics such as flexural strength, split tensile strength, shear strength, water absorption, etc. There is little documentation with regards to these other structural characteristics. These structural characteristics are required by structural engineers and related scientists for structural design computations. The lack of information on these leaves room for much speculation, approximations and arbitrariness, which could be detrimental to the design of structures.

In this work, laterite was replaced partially with river sand with a percentage range of 10% – 40% and the effect of the replacement was considered on the specified strength/mechanical properties.

2. MATERIALS AND METHODS

2.1. Materials

The following materials were used for the experimental investigation.

- Laterite: This was sourced from Ikeduru LGA, Imo State, Nigeria. The grading and properties conformed to BS 882 (1992).
- River sand: This was obtained from Otamiri River, in Imo State. The grading and properties of this fine aggregate conformed to BS 882 (1992).
- Cement: Eagle cement brand of ordinary Portland cement with properties conforming to British standard was used (BS 12 1978).
- Water: Potable water conforming to the specification of EN 1008:2002 was used.

2.2. Methods

The materials for the experimental investigation were sourced and transferred to Civil Engineering laboratory, Federal University of Technology, Owerri where they were spread and allowed to dry. Various tests and analysis were carried out on the laterite and river sand samples before the blocks were produced.

2.2.1. Physical property tests

The laterite was observed and tested to determine the physical properties. These include sieve analysis, specific gravity, moisture content, bulk density and plasticity index. The sieve analysis and plasticity index were carried out according to standard procedures (BS 812: 1985 and BS 1377: 1975).

2.2.2. Chemical property tests

Chemical analysis was carried out on the laterite sample to determine the chemical composition of the laterite. The quantities of various elements per kilogram of laterite sample were determined. These include calcium, iron, magnesium, potassium, sulphate, aluminium, etc.

2.2.3. Preparation of test specimens

The mix proportions were measured by weight and blocks of size 450 mm x 150 mm x 225 mm (solid) were produced. The blocks were demoulded immediately after manual compaction of newly mixed constituent materials in a mould. The blocks were cured for 28 days after 24 hours of demoulding using the environmentally friendly method of covering with tarpaulin/water proof devices to prevent moisture loss. The mix ratios prescribed for the laterite blocks made without river sand (used as control) are presented in Table 1. Laterite was replaced partially with sand using 10%– 40% replacement to produce the sand-laterite blocks. The mix ratios prescribed for the sand-laterite blocks are presented in Table 2.

2.2.4. Characteristics tests

In accordance to BS 2028, 1364, (1968), the blocks were tested for compressive strength, flexural strength, split tensile strength, shear strength and water absorption. The values were obtained using basic/standard equations that could be obtained from Neville (1981). Three samples were tested for each experiment and the average value was recorded. The characteristic tests were carried out on the control samples (laterite blocks without river sand) as well as the sand-laterite blocks.

C.E. Okere / Nigerian Research Journal of Engineering and Environmental Sciences
5(2) 2020 pp. 769-779

Table 1: Mix ratios prescribed for the laterite blocks made without river sand (Control)

Exp. no.	Mix ratios (w/c: cement:	Cement content (%)
1	0.8:1:8	10
2	1:1:12.5	8
3	1.28:1:16.67	6

Table 2: Mix ratios for sand-laterite blocks

Exp. no	Mix ratios (w/c: cement: sand: laterite)	% Replacement with river sand	Cement content (%)
1	0.8: 1: 3.2: 4.8	40	10
2	1: 1: 3.75: 8.75	30	8
3	1.28: 1: 3.334: 13.336	20	6
4	2.2: 1: 2.5: 22.5	10	4

3. RESULTS AND DISCUSSION

3.1. Physical Properties of Laterite

The summary of the physical property tests results of laterite are presented on Table 3 while the result of the grain size distribution is presented on Table 4. Table 3 summarises the physical properties of the laterite which is reddish-brown in colour. It has an easily mouldable consistency. The bulk density of laterite is 1.91 Mg/m^3. From literature, soil which shows massive structure and less porosity will show high bulk density from 1.6 to 1.7 Mg/m^3. Movement of water is hindered in such soils. Bulk density value of the laterite used in this work is higher than this range of value stipulated. Bulk density, which is an indicator of soil compaction, is inversely related to porosity of the same soil. It reflects the soil's ability to function as structural support, water and solute movement. The specific gravity of the laterite is 2.67. According to the British Soil Classification System (BSCS) the general range for specific gravity of clay and silty clay is 2.67 – 2.9 (BS 5930, 1981). Therefore, the laterite falls under this category. Specific gravity number indicates how much heavier or lighter a material is than water. The liquid limit value of the laterite is 49%. From BSCS, soils having liquid limit between 35% and 50% are said to have intermediate plasticity. Thus, with a liquid limit of 49%, the laterite used in this work can be said to have intermediate plasticity which makes it relatively easy to be moulded, crushed or squeezed in the hand. The plasticity index (PI) of the laterite is 37.12%. PI is the measure of the plasticity of a soil. It is the size of the range of water contents required for the soil to exhibit plastic properties. According to BSCS, soils with plasticity index between 20 and 40% are said to be of high plasticity which tend to be clay. Therefore, the laterite used in this work falls under this category of high plasticity. The implication of this is that the material can be moulded easily. A study of the particle size distribution (Table 4) shows that the laterite is well graded. Using the American Association of State Highway and Transportation Officials (AASHTO, 1986) classification system, this laterite can be described as clayey sand under group A-2-7.

Table 3: Summary of physical properties of laterite

Property	Value
Colour	Reddish brown
Consistency	Easily mouldable
Bulk density (Mg/ m^3)	1.91
Initial moisture content (%)	13.38
Dry density (Mg/ m^3)	1.68
Specific gravity	2.67
Liquid limit (%)	49.00
Plastic limit (%)	11.88
Plasticity index (%)	37.12

C.E. Okere / Nigerian Research Journal of Engineering and Environmental Sciences
5(2) 2020 pp. 769-779

Table 4: Grain size distribution of laterite

Sieve size (mm)	Weight of sieve (g)	Weight of sieve & sample (g)	Weight of sample retained (g)	Cumulative weight of sample retained (g)	Percentage finer (%)
4.75	496.0	496.0	-	-	100.00
2.00	410.0	427.0	17.0	17.0	96.60
1.18	402.0	485.9	83.0	100.0	80.00
0.850	384.00	474.2	90.0	190.0	62.00
0.600	381.2	516.0	134.8	324.8	35.04
0.425	486.0	561.0	75.1	399.9	20.02
0.300	366.0	413.3	47.3	447.2	10.56
0.150	312.0	358.0	46.0	493.2	1.36
0.075	345.1	350.9	5.8	499.0	0.20
Pan	273.0	274.0	1.0	500.0	-

3.2. Chemical Properties of Laterite

The results from the chemical property test of laterite are presented in Table 5. Table 5 shows the results of the chemical analysis of laterite. It shows that the laterite contains 120.11 mg of calcium (Ca) per kilogram of laterite sample. The oxide of the element, calcium constitutes about 63% of Ordinary Portland Cement (OPC). The presence of calcium in the laterite enhances the complete hydration of OPC and consequently, the development of strength. According to Neville (1981), the raw materials used in the manufacture of Portland cement, consist mainly of lime, silica, alumina and iron oxide. Generally, the chemical analysis of the laterite reveals that it contains some quantities of these oxides. The iron content is 29.5 mg/kg (a high range value), and this accounts for the reddish colour of the laterite. About 0.5 to 6.0% of oxide of iron is present in OPC. The laterite contains 15.67 mmoles of $H^+ + Al^{3+}$ per kilogram of laterite sample. In addition, 3 to 8% of the oxide of aluminium is present in OPC. Table 9 also shows that the laterite contains 100.44 mg of magnesium (Mg) per kilogram of laterite sample. OPC contains about 0.1 to 4.0% of magnesium oxide. The laterite contains 6.08 mg of sulphate (SO_4^{2-}) per kilogram of laterite sample. A combination of calcium, sulphate and water gives gypsum (Ca $SO_4.2H_2O$). Gypsum is usually added to cement clinker to prevent 'flash set' (immediate stiffening of paste). Potassium (K) was not detected in the analysis. The oxide of potassium is a minor compound which is not of importance as far as strength is concerned. The cation exchange capacity was 22.86 mmoles/kg which is very effective.

Table 5: Chemical analysis of laterite

Component	Content
pH	6.04
Fe (mg/kg)	29.5
Zn (mg/kg)	22.26
$S0_4^{2-}$(mg/kg)	6.08
Ca (mg/kg)	120.11
Mg (mg/kg)	100.44
K (mg/kg)	0.00
$H^+ + Al^{3+}$ Exchangeable acidity (mmol/kg)	15.67
CEC Cation exchange capacity (mmol/kg)	22.86

3.3. Characteristics of Produced Blocks

The characteristics test results were determined and calculated using equations given in methods section, and then presented on Tables 6 to 15. Table 6 gives the compressive strength test results of laterite blocks made without river sand (this serves as the control) while Table 7 presents the compressive strength of the blocks made with both laterite and sand. Table 8 gives the flexural strength test results of laterite blocks made without river sand (this serves as the control) while Table 9 presents the flexural strength of the blocks made with both laterite and sand. Table 10 gives the split tensile strength test results of laterite blocks made without river sand (this serves as the control) while Table 11 presents the split tensile strength of the block made with both laterite and sand. Table 12 gives the shear strength test results of laterite blocks made without river sand (this serves as the control) while Table 13 presents the shear strength of the blocks made with both laterite and sand. Table 14 gives the water absorption test results of laterite blocks made without river sand (this serves as the control) while Table 15 presents the water absorption of the blocks made with both laterite and sand.

The effects of the partial replacement of laterite with river sand on the properties of the blocks could be seen vividly from the test results shown in Tables 6 to 15. Considering specifically, the compressive strength test results, the control sample (without river sand) with mix ratio of 0.8:1:8 gave a strength value of 2.148 N/mm^2 while the sand-laterite sample with 40% sand replacement and mix ratio of 0.8:1:3.2:4.8 gave a strength value of 3.012 N/mm^2 (Tables 6 and 7). The control sample (without river sand) with mix ratio of 1:1:12.5 gave a strength value of 0.963 N/mm^2 while the sand-laterite sample with 30% sand replacement and mix ratio of 1:1:3.75:8.75 gave a strength value of 2.025 N/mm^2. The control sample (without river sand) with mix ratio of 1.28:1:16.67 gave a strength value of 0.914 N/mm^2 while the sand-laterite sample with 20% sand replacement and mix ratio of 1.28:1:3.334:13.336 gave a strength value of 1.630 N/mm^2. These show an increasing trend in the values as the percentage replacement increases and vice versa. This trend could also be seen in the results of the flexural, split tensile and shear strength values shown in Tables 8 to 13.

Generally, it can be observed from the tests results that the partial replacement of laterite with sand improved the quality of the blocks. Comparing the results from the control samples with the samples made with a percentage of sand, the compressive strength, flexural strength, split tensile strength, and shear strength values increased significantly with inclusion of sand in the mix. Furthermore, the variation of these properties with percentage replacement shows increasing trends in the properties as the percentage replacement increased.

Table 6: Compressive strength test results of laterite blocks made without river sand (Control)

Exp. No.	Mix ratios (w/c: cement: laterite)	Replicates	Mass (kg)	Density (kg/m^3)	Average density (kg/m^3)	Failure load (kN)	Cross sectional area (mm^2)	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
1	0.8:1:8	A	23.6	1553.91	1533.89	145	67500	2.148	2.148
		B	23.2	1527.57		140		2.074	
		C	23.1	1520.99		150		2.222	
2	1:1:12.5	A	22.0	1448.56	1461.73	70	″	1.037	0.963
		B	22.5	1481.48		69		1.022	
		C	22.1	1455.14		56		0.830	
3	1.28:1:16.67	A	21.7	1428.81	1426.61	60	″	0.889	0.914
		B	21.7	1428.81		75		1.111	
		C	21.6	1422.22		50		0.741	

C.E. Okere / Nigerian Research Journal of Engineering and Environmental Sciences
5(2) 2020 pp. 769-779

Table 7: Compressive strength test results of sand-laterite blocks

Exp. No.	Mix ratios (w/c: cement: sand: laterite)	Replicates	Mass (kg)	Density (kg/m^3)	Average density (kg/m^3)	Failure load (kN)	Cross sectional area (mm^2)	Compressive strength (N/ mm^2)	Average comp. strength (N/ mm^2)
1	0.8:1:3.2:4.8	A	24.5	1613.17	1619.75	180	67500	2.667	3.012
		B	24.7	1626.34		220		3.259	
		C	24.6	1619.75		210		3.111	
2	1:1: 3.75 :8.75	A	22.6	1448.06	1569.27	130	″	1.926	2.025
		B	25.1	1652.67		140		2.074	
		C	23.8	1567.08		140		2.074	
3	1.28:1:3.334:13.336	A	23.0	1514.40	1516.60	100	″	1.482	1.630
		B	23.1	1520.99		110		1.630	
		C	23.0	1514.40		120		1.778	
4	2.2: 1:2. 5:22 .5	A	23.1	1520.99	1534.17	80	″	1.185	1.259
		B	23.5	1547.35		90		1.333	
		C	23.3	1534.16		85		1.259	

Table 8: Flexural strength test results of laterite blocks made without river sand (Control)

Exp. No.	Mix ratios (w/c: cement: laterite)	Replicates	Mass (kg)	Density (kg/m^3)	Average density (kg/m^3)	Failure load (kN)	Flexural strength (N/ mm^2)	Average flexural strength (N/ mm^2)
1	0.8:1:8	A	18.2	1797.53	1774.49	15.5	1.378	1.452
		B	18.2	1797.53		17.5	1.556	
		C	17.5	1728.40		16.0	1.422	
2	1:1:12.5	A	15.2	1501.23	1547.32	2.5	0.222	0.261
		B	16.0	1580.25		3.5	0.311	
		C	15.8	1560.49		2.8	0.249	
3	1.28:1:16.67	A	17.3	1708.64	1609.88	2.5	0.222	0.231
		B	15.3	1511.11		2.3	0.204	
		C	16.3	1609.88		3.0	0.267	

Table 9: Flexural strength test results of sand-laterite blocks

Exp. No.	Mix ratios (w/c: cement: sand: laterite)	Replicates	Mass (kg)	Density (kg/m^3)	Average density (kg/m^3)	Failure load (kN)	Flexural strength (N/ mm^2)	Average flexural strength (N/ mm^2)
1	0.8:1:3.2:4.8	A	17.6	1738.27	1823.87	17.5	1.555	1.718
		B	19.0	1876.54		21.5	1.911	
		C	18.8	1856.79		19.0	1.689	
2	1:1:3.75:8.75	A	19.8	1955.56	1919.34	13.5	1.200	1.170
		B	19.0	1876.54		12.0	1.067	
		C	19.5	1925.93		14.0	1.244	
3	1.28:1:3.334:13.336	A	19.0	1876.54	1771.19	6.5	0.578	0.590
		B	16.1	1590.12		3.5	0.311	
		C	18.7	1846.91		9.9	0.880	
4	2.2:1:2.5:22.5	A	18.9	1866.67	1896.30	13.0	1.160	0.861
		B	19.5	1925.93		5.0	0.444	
		C	19.2	1896.30		11.0	0.978	

C.E. Okere / Nigerian Research Journal of Engineering and Environmental Sciences
5(2) 2020 pp. 769-779

Table 10: Split tensile strength test results of laterite blocks made without river sand (Control)

Exp. No.	Mix ratios (w/c: cement: laterite)	Replicates	Mass (kg)	Density (kg/m^3)	Average density (kg/m^3)	Failure load (kN)	Split tensile strength (N/ mm^2)	Average split tensile strength (N/ mm^2)
1	0.8:1:8	A	23.7	1560.49	1545.14	45	0.283	0.293
		B	23.2	1527.57		45	0.283	
		C	23.5	1547.35		50	0..314	
2	1:1:12.5	A	22.7	1494.65	1474.90	10	0.063	0.094
		B	22.5	1481.48		15	0.094	
		C	22.0	1448.56		20	0.126	
3	1.28:1:16.67	A	21.8	1435.39	1433.20	20	0.126	0.157
		B	21.6	1422.22		25	0.157	
		C	21.9	1441.98		30	0.189	

Table 11: Split tensile strength test results of sand-laterite blocks

Exp. No.	Mix ratios (w/c: cement: sand: laterite)	Replicates	Mass (kg)	Density (kg/m^3)	Average density (kg/m^3)	Failure load (kN)	Split tensile strength (N/ mm^2)	Average split tensil strength (N/ mm^2)
1	0.8:1:3.2:4.8	A	24.8	1632.92	1621.95	80	0.503	0.472
		B	24.5	1613.17		70	0.440	
		C	24.6	1619.75		75	0.472	
2	1:1:3.75:8.75	A	23.4	1540.74	1582.44	30	0.189	0.210
		B	24.8	1632.92		35	0.220	
		C	23.9	1573.66		35	0.220	
3	1.28:1:3.334:13.336	A	23.5	1547.35	1549.53	30	0.189	0.199
		B	23.6	1573.66		30	0.189	
		C	23.2	1527.57		35	0.220	
4	2.2:1:2.5:22.5	A	22.9	1507.82	1520.99	40	0.252	0.241
		B	23.1	1520.99		35	0.220	
		C	23.3	1534.16		40	0.252	

Table 12: Experimental values of shear strength of laterite blocks made without river sand (Control)

Exp. No.	Mix ratios (w/c: cement: laterite)	Replicates	Failure load in flexure (kN)	Shear load (kN)	Cross sectional area (mm^2)	Shear strength (N/ mm^2)	Average shear strength (N/ mm^2)
1	0.8:1:8	A	15.5	7.75	22500	0.344	0.363
		B	17.5	8.75	″	0.389	
		C	16.0	8.00	″	0.356	
2	1:1:12.5	A	2.5	1.25	″	0.056	0.065
		B	3.5	1.75	″	0.078	
		C	2.8	1.40	″	0.062	
3	1.28:1:16.67	A	2.5	1.25	″	0.056	0.058
		B	2.3	1.15	″	0.051	
		C	3.0	1.5	″	0.067	

C.E. Okere / Nigerian Research Journal of Engineering and Environmental Sciences
5(2) 2020 pp. 769-779

Table 13: Experimental values of shear strength of sand-laterite blocks

Exp. No.	Mix ratios (w/c: cement: sand: laterite)	Replicates	Failure load in flexure (kN)	Shear load (kN)	Cross sectional area (mm^2)	Shear strength (N/ mm^2)	Average shear strength (N/mm^2)
1	0.8:1:3.2:4.8	A	17.5	8.75	22500	0.389	0.430
		B	21.5	10.75	″	0.478	
		C	19.0	9.5	″	0.422	
2	1:1:3.75:8.75	A	13.5	6.75	″	0.300	0.293
		B	12.0	6.0	″	0.267	
		C	14.0	7.0	″	0.311	
3	1.28:1:3.334:13.336	A	6.5	3.25	″	0.144	0.147
		B	3.5	1.75	″	0.078	
		C	9.9	4.95	″	0.220	
4	2.2:1:2.5:22.5	A	13.0	6.5	″	0.289	0.215
		B	5.0	2.5	″	0.111	
		C	11.0	5.5	″	0.244	

The trend in the water absorption rate with percentage replacement (Tables 14 and 15) is entirely different from those of the mechanical properties. Increased water absorption rate increases the rate at which water or any other fluid is absorbed by the block and vice versa. Considering experiment number one, the laterite (control) blocks with mix ratio of 0.8:1:8 attained a saturation of 2.72% while the sand-laterite blocks with 40% sand replacement and mix ratio of 0.8:1:3.2:4.8 attained a saturation of 5.42% under 24 hours of total immersion in water. The control sample (without river sand) with mix ratio of 1:1:12.5 gave a water absorption rate of 5.57% while the sand-laterite sample with 30% sand replacement and mix ratio of 1:1:3.75:8.75 gave a water absorption rate of 6.85%. The control sample (without river sand) with mix ratio of 1.28:1:16.67 gave a water absorption rate of 6.14% while the sand-laterite sample with 20% sand replacement and mix ratio of 1.28:1:3.334:13.336 gave a water absorption rate of 7.19%. This indicates that water absorption rate increased with addition of sand in the mix proportions.

However, the laterite blocks (control) have lower water absorption values than the sand-laterite blocks which contain sand in the mix. Considering experiment number one, the laterite blocks attained a saturation of 2.72% while the sand-laterite blocks attained a saturation of 5.42% under 24 hours of total immersion in water. This shows that laterite blocks are less permeable than sand-laterite blocks. In as much as the strength increased with inclusion of sand in the mix, it should be noted that the permeability increased with addition of sand hence reducing its durability.

Table 14: Water absorption test results of laterite blocks made without river sand (Control)

Exp. No.	Mix ratios (w/c: cement: laterite)	Replicates	Dry mass (kg)	Wet mass (kg)	Absorption (%)	Average absorption (%)
1	0.8:1:8	A	23.6	24.4	3.39	2.72
		B	23.0	23.5	2.17	
		C	23.2	23.8	2.59	
2	1:1:12.5	A	22.5	23.7	5.33	5.57
		B	22.1	23.3	5.43	
		C	21.8	23.1	5.96	
3	1.28:1:16.67	A	21.7	23.1	6.45	6.14
		B	21.8	22.0	5.5	
		C	21.6	22.9	6.48	

Table 15: Water absorption test results of sand-laterite blocks

Exp. No.	Mix ratios (w/c: cement: sand: laterite)	Replicates	Dry Mass (kg)	Wet Mass (kg)	Absorption (%)	Average absorption (%)
1	0.8:1:3.2:4.8	A	24.3	25.5	4.90	5.42
		B	24.7	26.1	6.07	
		C	24.5	25.8	5.30	
2	1:1:3.75:8.75	A	22.9	24.4	6.55	6.85
		B	24.8	23.6	6.05	
		C	23.9	25.8	7.95	
3	1.28:1:3.334:13.336	A	23.3	25.1	7.73	7.19
		B	23.6	25.1	6.36	
		C	23.4	23.35	7.48	
4	2.2:1:2.5:22.5	A	22.9	24.1	5.24	5.49
		B	23.1	24.5	6.06	
		C	23.2	24.4	5.17	

4. CONCLUSION

1. The values of the stated mechanical properties increased significantly with the inclusion of sand in the mix. Furthermore, the variation of these properties with percentage replacement shows increasing trends in the properties as the percentage replacement increased.
2. The laterite blocks (control) have lower water absorption values than the sand-laterite blocks which contain sand in the mix. This shows that laterite blocks are less permeable than sand-laterite blocks.
3. Introduction of conventional river sand into the block mix proportions can increase the mechanical properties but reduce the durability assessed by the water absorption rate.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

AASHTO, (1986). Standard specification for transportation, materials and method of testing and sampling. Washington D.C., USA: American Association of State Highway and Transportation Officials.

Adam, E.A. (2001). Compressed stabilised earth blocks manufactured in Sudan. A publication for UNESCO [online]. Available from: http://unesdoc.unesco.org.

Adegun, O. B. and Adedeji, Y.M.D. (2017). Review of economic and environmental benefits of earthen materials for housing in Africa. *Fontiers of Architectural Research*, 6(4), pp. 519-528.

Agbede, I.O. and Manasseh, J. (2008). Use of cement-sand admixture in lateritic brick production for low cost housing. *Leonardo Electronic Journal of Practices and Technology*, 12, pp. 163-174.

Aguwa, J.I. (2010). Performance of laterite-cement blocks as walling units in relation to sandcrete blocks. *Leonardo Electronic Journal of Practices and Technologies*, 9(16), pp. 189-200.

Boeck, L., Chaudhuri, K.P.R. and Aggarwal, H.R. (2000). Sandcrete blocks for buildings: A detailed study on mix compositions, strengths and their costs. *The Nigerian Engineer*, 38 (1), pp. 24-33.

British Standard Institution (BS) (1981). BS 5930:1981 British Soil Classification System for Engineering Purposes (BSCS) - British Standard Code of practice for site investigation.

British Standard Institution (BS) (1975). BS 1377: 1975. Methods of test for soils for Civil Engineering purposes.

British Standards Institution, (BS) (2002). BS EN 1008:2002: Mixing water for concrete – Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete.

British standard Institution (BS) (1985). BS 812: Section 103.1:1985. Sieve tests.

British Standard Institution (BS) (1992). BS 882:1992, Specification for aggregates from natural sources for concrete.

British Standards Institution (BS) (1978). BS 12:1978, Specification for Portland cement.

British Standard Institution (BS) (1968). BS 2028, 1364: 1968. Specification for precast concrete blocks.

Komolafe, O.S. (1986). A study of the alternative use of laterite-sand-cement. In: Proceedings of the Materials Testing and Control, University of Science and Technology, Owerri, Imo State, Feb. 27-28, 1996.

Madedor, A.O. (1992). The impact of building materials research on low cost housing development in Nigeria. *Engineering focus: Publication of the Nigerian Society of Engineers,* 4(2), pp. 37-41.

Neville, A.M. (1981). *Properties of concrete*. 3rd ed. London: Pitman.

Okere, C.E. and Onwuka, D.O. (2016). Water absorption of soilcrete blocks. In: Proceedings of the 2016 Engineering & Technology Conference & Exhibition, Akanu Ibiam Federal Polytechnic Unwana, Ebonyi State.

Okere, C.E. (2017). Suitability and Advantages of Using Laterite as a Soilcrete Block Material. *IJournals: International Journal of Architectural Science & Civil Engineering*, 1 (1), pp. 1-8.