Comparative Study of Cement Stabilized Clay Brick and Sandcrete Block as a Building Component

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Abstract

This study analyzed the engineering properties and cost of production of cement stabilized clay bricks and sandcrete blocks with a view to comparing the findings with cement stabilized clay bricks and hollow sandcrete blocks sold in Oke-Baale area of Osogbo, Osun State, Nigeria. Materials employed by the study are; clay, cement, sand, water and mold. Atterberg limit test was carried out in the laboratory to establish the plastic limit, liquid limit and plasticity index of the clay soil. Results show that; averagely, liquid limit is 58.5, plastic limit is 35.69 and plasticity index is 22.82 for the clay soil which favorably compared with recommended classifications, locally and internationally. The results further indicate that the compressive strength of the clay bricks for different mix ratios range from 1.14N/mm^2-1.49/mm^2 as curing age increases from 7 to 28 days, considering cement/clay mix ratio of 1:12. Cement/clay ratio of 1.5:12 gives a compressive strength of 1.2N/mm^2 – 1.47N/mm^2 for the same 7 to 28 days. Results also indicate that the compressive strength of 225mm and 150mm sandcrete hollow blocks vary from 0.85N/mm^2 to 1.33N/mm^2 for cement/sand mix ratio 1:12 and 0.92N/mm^2 to 1.39N/mm^2 for mix ratio 1.5:12 respectively; for curing period of 7 to 28 days. The cost per square metre of 150mm and 225mm sandcrete hollow blocks are ₦1, 440.00 and ₦1, 648.08 respectively, while that of clay cement stabilized block is ₦1, 682.45 per square metre. The study recommends a reduction in the cement/sand and cement/clay mix ratios employed for both sandcrete hollow blocks and cement stabilized clay bricks to ratio 1:8 or 1:7 to enable the blocks to achieve the recommended 2-2.5N/mm^2 compressive strength for load bearing wall component in building NIS 87 (2004).

Keywords: Walling component; stabilized clay brick; sandcrete blocks; mix ratio, Oke-Baale

1. Introduction

Clay bricks have been an important component of building in Nigeria before the advent of sandcrete blocks. Especially in the South-West zone of the country, locally made bricks were the major component as walling material in a building. According to Raheem, Momoh, and Soyingbe (2012), walling materials in any building contributes about 22% of the total building cost.

Stating that the choice of a walling material are based on various factors such as; cost, durability, aesthetics, and ability to weather the immediate environmental conditions. For the purpose of this study, sandcrete blocks will be assumed to be blocks molded with cement, sand and water in a 450mmx225mmx225mm and 150mmx225mmx450mm molds and machine vibrated. While the cement stabilized brick is molded with cement, clay and water and vibrated with a locally made block machine. Soil stabilization may be referred to as any process aimed at improving the performance of a soil as construction material. Bell (1993), referred to soil stabilization as the process of mixing additives with soil to improve its volume stability, strength, permeability, and durability. The soil that is of concern in this study is clay; it is found in hot and wet tropical areas where natural drainage is impeded (Lasisi and Osunde, 1984). This type soil abounds all over Nigeria and forms the major topography of Oke-Baale and Osun State in general. SMEs and individuals take advantage of the abundance to commercialize the use through the production of clay brick blocks. Stabilized Clay or laterite blocks is a product introduced into the Nigeria market by (NBRRI) Nigeria Building and Road Research Institute based on the abundance of clay soil in Nigeria. According to Mahalinga-Iyer and Williams (1997), lateritic clay soil abounds in tropical and sub-tropical countries. Improved technology has emboldened entrepreneurs to start producing stabilized clay bricks as alternative to sandcrete blocks as walling component in building. Against this backdrop, this study carries out a comparative analysis of sandcrete hollow blocks and cement stabilized blocks produced around the Oke-Baale area of Osogbo by evaluating their mechanical properties and production cost.

2. Methodology

Materials used for producing sandcrete hollow blocks and clay bricks were purchased from the Oke-Baale area of Osogbo.

2.1. Materials

Cement: The cement used was Elephant cement an Ordinary Portland Cement (OPC) purchased from a cement depot in Oke-Baale, Osogbo, and it conformed to BS 12 (1978) as confirmed by Yahaya (2008).

Sand: Sand collected from a borrow pit around the Osun State University, Osogbo, Osun State, Nigeria and used generally around Oke-Baale area for molding blocks; was clean, sharp, free from clay and organic matter and well graded in conformity to BS 882 (1983).

Water: water from the laboratory tap was used for mixing; it was ensured that it was fit for drinking, free from contaminants either dissolved or in suspension as specified by BS 3148 (1980).

Lateritic Clay Soil: The lateritic clay soil used in the study was obtained from a borrow pit in Osogbo, Nigeria (Latitude7.46' North and Longitude 4.34' East) between a depth of 1.5m to 2.0m using method of disturbed sampling. (See table 1 for the index properties of the natural soil).

Laboratory Tests: All laboratory tests on clay and sharp sand for the purpose of characterization including natural moisture content, particle size distribution, Atterberg limits tests, compaction, compressive and specific gravity tests were carried out according to BS 1377 (1990).

Mixing & Molding: Mixes of Cement/Sand ratio 1:12 (1 head pan of cement to 12 head pans of sand), 1.5:12 (1.5 head pans of cement to 12 head pans of sand) and Cement/Clay ratio 1:12 (1 head pan of cement to 12 head pans of clay soil) and 1.5:12 (1.5 head pans of cement to 12 head pans of clay soil) respectively were prepared and 35 blocks of 225mm, 40 blocks of 150mm and 40 bricks were molded for each mix. A total of 150 hollow sandcrete blocks of the various sizes and 150 cement stabilized clay bricks of size 230mm x 230mm x 115mm were produced and cured under laboratory conditions for 7, 21, and 28 days curing periods. Compaction test was carried out in accordance with BS 1377 (1990).

Compressive Strength Test: An electrically operated Impact compression machine of 2000 KN capacity was employed in carrying out the compressive test on the blocks and bricks with reference to BS 1881 (1983), at the curing period of 7, 14, 21, and 28 days respectively. 12 blocks and bricks were crushed each day for the different mix ratios of sand and clay and the average compressive strength recorded. The test was carried out in compliance with recommendation from Neville (2000).

Density Test: Densities of the stabilized clay-cement and sandcrete hollow blocks were determined in accordance with NIS 87 (2004) and results shown in Table 2.

Cost Analysis: Cost analysis at the time of this study was based on per square metre of both clay bricks and sandcrete blocks respectively and results are presented in findings and discussion below.

3. Findings and Discussion

3.1. Test for Engineering Properties of Clay and Sand

The index properties of the sand and clay used for the study are summarized in Table 1 while Figure 1 shows their particle size distribution. The sand was well graded and classified in zone 1 according to BS 882 (1983), and it is in agreement with the provisions of BS 1377 (1990) for clean quartz and flint sands. An investigation into the geotechnical and engineering properties of sample as well as study of soil maps of Nigeria based on the findings of Akinola (1982) indicated that the sample used by the study belong to the group of ferruginous tropical soils derived from acid igneous and metamorphic rocks.

3.2. Compressive Strength Results

The result of compressive strengths test for the 150mm, 225mm and cement stabilized clay bricks at various cement/sand mix ratios are presented in figures 1 to 3 below. The graph for the 150mm sandcrete block shows a gradual increase in strength from seven days to 28 days curing period for the 1:12 cement to sand mix. However, the 1.5 cement to sand mix ratio shows a rapid increase in the compressive strength for the same period. While the 225mm graph shows only a slight difference but it is worthy to note that the ratio 1.5:12; cement/sand gained strength faster than the other mix ratio. Figure 3 depicts almost the same result except that; there is a slight increase in the total strength gained than it is noticed in the sandcrete blocks. The slight increase in compressive strength noticed in the ratio 1.5:12, may be due to increased bonding with the aggregates of the blocks and bricks which could as well increase the density. According to Metcalfe (1977), the strength increases in blocks is directly proportional to the cement content, but at different rates for different soils which is apparent in the results shown in the graphs below. Meaning higher cement contents will result in higher cost of production; reason the average block maker will increase the cement/sand ratio in order to bring down the cost of production. This results in low compressive strength and may lead to building collapse.

3.3. Comparison of Cost of Production between Sandcrete Blocks and Cement Stabilized Bricks

3.3.1. Cost per Square Metre of Sandcrete Blocks and Cement Stabilized Bricks

The unit cost of the sandcrete hollow blocks and clay bricks were calculated;

Mix Ratio = 1:12 (that is; one head pan of ordinary Portland cement to twelve head pans of sharp sand). This translates to one bag of ordinary Portland cement to twenty four head pans of sand, since there are two head pans in a bag of cement.

The cost of one bag of ordinary Portland cement is ₦1,700 as at the time of carrying out this study.

24 head pans of sharp sand @ ₦ 120	= ₦2,880
1 bag of cement @ ₦ 1,700	= ₦1,700
Total	**= ₦4,580**
For 225mm block @ ₦ 4,580 produced 35 blocks.	
Cost of materials for producing 1 unit of 225mm sandcrete block	= ₦130.90
Assume 10% for labour	= ₦13.90
Total cost incurred in producing one unit of 225mm sandcrete hollow block	= **₦144.80**
For 150mm block, ₦4,580 produced 40blocks.	
Cost of materials for producing 1 unit of 150mm sandcrete block	= ₦114.50
Assume 10% for labour	= ₦11.45
Total cost incurred in producing one unit of 150mm sandcrete hollow block	**= ₦125.95**

Mix Ratio 1.5:12 (that is, one and half head pans of ordinary Portland cement: twelve head pans of clay soil).
Cost of buying 1 head pan of clay = ₦50.00

The cost of one bag of ordinary Portland cement is ₦1,700 as at the time of carrying out this study.

Cost of 12 head pans of Clay soil	=		₦600.00
Cost of 1 head pan of Cement	=		₦850.00
Polythene sheet for curing	=		₦200.00
Cost of materials used	=		**₦1,650.00**
₦ 1,650.00 was used to produce 40 clay bricks			
Cost of producing one unit of clay brick	=	₦1,650.00/40	= ₦41.25

Assume 10% for labour = ₦4.13
Total cost incurred in producing one unit of clay brick = **₦45.38**

3.3.2. Cost per Square Metre of Sandcrete Blocks and Clay Bricks Wall

Elevation area of sandcrete block = 0.450m x 0.225m = 0.10125m^2
Number of sandcrete blocks in one square metre = 9.87
Approximately 10 Blocks
Cost of 225mm sandcrete hollow blocks per square metre = 10 x 144. 80 = ₦1,448.00
Assume 10% for cost of mortar for laying the blocks = ₦144.80
Assume another 10% for labour for laying the block = ₦144.80
Total cost per square metre for 225mm sandcrete blocks = **₦1,737.60**

Cost of 150mm sandcrete hollow blocks per square metre = 10 x 125.95 = ₦1,259.50
Assume 10% for cost of mortar for laying the blocks = ₦125.95
Assume 10% for labour for laying the blocks = ₦125.95
Total cost per square metre for 150mm sandcrete blocks = **₦1,511.40**

Elevation area of clay bricks = 0.230m x 0.115m = 0.02645
Number of clay bricks in one square metre = 37.81
Approximately 38 Bricks
Cost of clay bricks per square metre = 38 x 45.38 = ₦1,724.44
Assume 15% for labour (more blocks involved) = ₦258.67
Total cost per square metre for clay bricks = **₦1,983.11**

3.4. Cost Analysis

The above results show the various cost for the production of 150mm and 225mm hollow sandcrete blocks alongside the cost of producing cement stabilized brick blocks.

The unit and per square metre cost of production, is highlighted. At the time of carrying out the study, a unit cost of 150mm hollow sandcrete block was ₦125.95; 225mm size cost, ₦144.80; cement stabilized bricks on the other hand cost, ₦53.63 respectively. This cost favorably compared with the retail cost of the same products around the study area. At the time the study was carried out, 150mm and 225mm hollow sandcrete blocks were sold at a retail price of ₦120.00 and ₦150.00 per unit respectively. The ₦45.38 cost of a unit of brick also compares to the ₦60.00/unit retail cost around the study area. The per square metre cost of the cement stabilized bricks seem slightly higher than the hollow blocks, reason being the size and number that makes up a square metre.

4. Conclusion

From the results presented above, the following conclusions can be made:

- The unit cost of cement stabilized bricks is lower than that of hollow sandcrete blocks.
- The compressive strength of cement stabilized bricks is slightly higher than that of the hollow sandcrete blocks.
- All the blocks produced and tested, meet the minimum required compressive strength for use as a wall component in building.
- The square metre cost of cement stabilized bricks was slightly higher than that of hollow sandcrete blocks.
- That Cement stabilized bricks compared favorably with hollow sandcrete blocks in terms of engineering properties.

5. *Recommendations*

The study recommends as follows:

- That the mix ratio cement/sand should be reduced to 1:8 or 1:7 for the production of retailed blocks to achieve the recommended load bearing compressive strength of between 3.0 to 5.0N/mm^2
- That cement stabilized clay bricks should be recommended by designers as an alternative wall component in Nigeria.

6. Tables and Figures

Table 1: Properties of the Clay Soil and Sand

Property	Laterite-Clay Soil	Sand
Natural Moisture Content (%)	6.92	1.45
Percentage passing BS No. 200 sieve (75µm) (%)	40	0
Liquid limit (%)	58.5%	-
Plastic limit (%)	35.69%	-
Plasticity index (%)	22.82%	-
Linear shrinkage	11.5	-
AASHTO classification	A-7-5 and A-7-6	
Maximum dry density (kg/m^3)	2013	-
Optimum Moisture Content (%)	15.73	-
Specific Gravity	3.0	2.67
Condition of Sample	Air - dried	Air- dried
Colour	Brownish - red	Brown

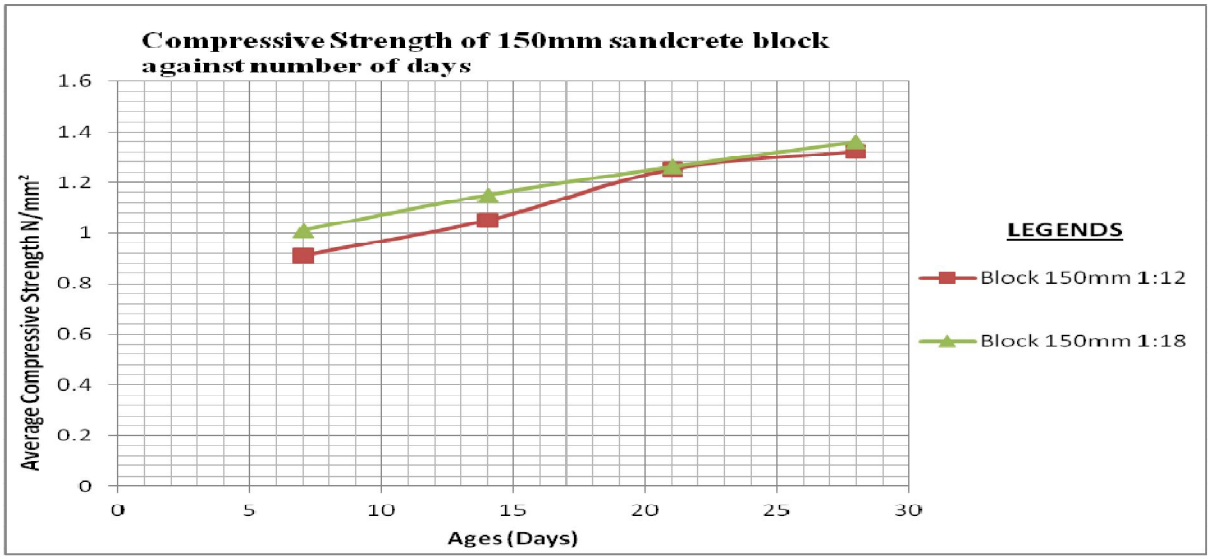

Figure 1: 7 – 28 Days Compressive Strength of 150mm Sandcrete Blocks

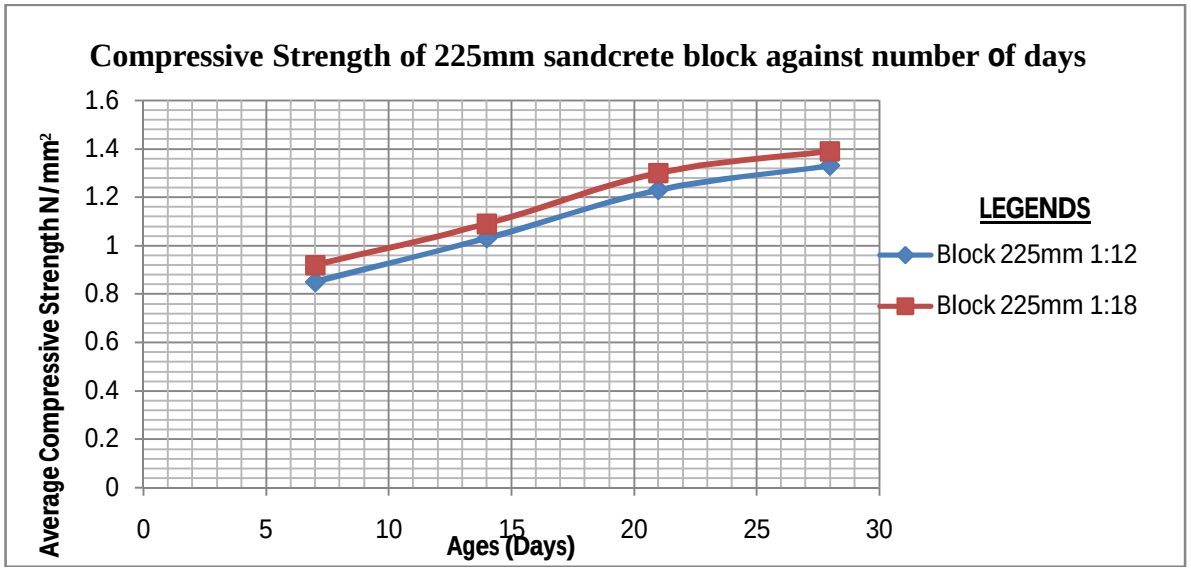

Figure 2: 7 – 28 Days Compressive Strength of 225mm Sandcrete Blocks

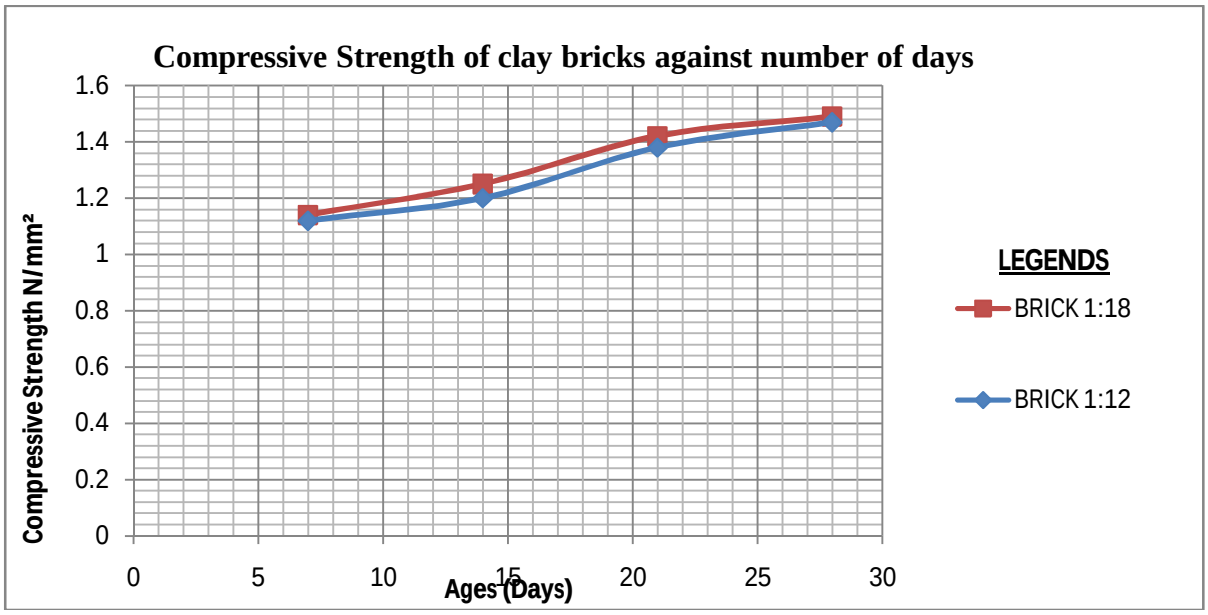

Figure 3: 7 – 28 Days Compressive Strength of Cement Stabilized Clay Bricks

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