Comparative Strength Analysis of Laterite as Partial Replacement of Sand in Hollow Blocks and Interlocking Bricks Production

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Abstract- Increase in demand of construction materials in Nigeria has made researchers work extensively on the need to incorporate locally products into production of sand hollow blocks and interlock bricks. This study analyzed the strength and durability of blocks and bricks blended with laterite as a partial replacement of sharp sand at 10, 20 and 30% respectively. A total of seventy-two (72) hollow blocks were produced manually using prefabricated steel moulds of 450mm x 225mm x 150mm and forty-eight (48) interlocking blocks with a mould of 200mm x 100mm x 85mm were subjected to water absorption, density and compressive strength tests. The results showed that 7 and 28 days average compressive strength of nine (9) inches blocks at 10% replacement was 0.76- 1.48N/mm^2 and 0.57- 1.30N/mm^2 at 30%. However, all blocks produced do not conform to NIS 87:2007 specification- 1.8N/mm^2 at age 7days and 2.5N/mm^2 at age of 28days. The average compressive strength of the interlocking blocks varied from 1.45N/mm^2- 2.57N/mm^2 and 1.24N/mm^2- 2.33N/mm^2 as the percentage replacement was increased from 0 to 30%, at day 7 and 28 of curing. All laterite interlocking blocks satisfied the minimum 28 days compressive strength of 1.0N/mm^2 recommended by the Nigeria Building and Road Research Institute (NBRRI, 2006). Proper curing and stabilization of laterite were suggested to improve the performance and quality of the hollow and interlocking blocks.

Indexed Terms- Sand hollow blocks, Interlocking bricks, Sharp sand and Laterite

I. INTRODUCTION

An efficient construction industry is a pre-requisite to effective national development since building, civil and industrial engineering works are usually a major contributor to Gross Fixed Capital Formation (GFCF), Gross Domestic Product (GDP) and National Employment of any nation (Oyewobi and Ogunsemi, 2010).

The necessity for shelter has always been one of the most important needs of man. The major component of any kind of shelter is its wall (Ogah and Igbe, 2016). Walling materials constitute an essential element in housing delivery. It is estimated that it covers about 22% of the total cost of a building. The choice of walling material is a function of cost, availability of material, durability, aesthetics and climatic condition (Raheem et al., 2012).

Sandcrete block is one walling material which has arguably revolutionized the construction industry in Nigeria (Baiden and Tuuli, 2004). This has made it an essential element in the building construction industry due to their availability, versatility, and durability. Block molding industry is one of the largest production sectors of the construction industry in Nigeria (Sholanke et al., 2015). Sandcrete blocks are most widely used in building and civil engineering works (i.e. load bearing and non–load bearing walls) as an essential element in the construction industry due to its availability, versatility, and durability to provide shelter for security of lives and properties (Ewa and Ukpata, 2013).

Nigerian Industrial Standard (NIS) 87:2007 defines sandcrete block as a composite material made up of cement, sand and water. The strength of sandcrete blocks depend upon two major factors namely; mix proportion and method of curing (Aiyewalehimi and Tanimola, 2013). The other factors include the quality of the constituents and the mode of manufacturing (i.e. hand mould and fabricated mould). Sand-crete hollow blocks are the predominant masonry units for building construction in Nigeria. In Engineering field, sand-crete is considered to be similar to concrete and is expected to exhibit properties similar to that of concrete except perhaps for the lower strength of sand-crete. Several studies have been carried out on the production and uses of sandcrete hollow blocks ranging from the low cost production to improved production output (Aderibigbe et al., 2017). Oyekan and Kamiyo (2008) observed that instead of the standard mix proportion of one part of cement to six parts coarse sand (1:6) by volume, many local sand-crete block manufacturers use a mix proportion of 1:8 instead. Also, sand-crete block manufacturers combine sharp sand with fine sand, clay or granite dust in a bid to improve its plasticity and this practice will not only weaken the bond between cement and the constituents in the green state, it could have a deleterious effect on the compressive strength of the blocks (Anosike and Oyebade, 2012). Laterite are residual sedimentary rocks, reddish or brownish colored, comparatively soft rocks, containing high degree of porosity and are carrying vermiform structures (Prasad and Parthasarathy, 2016). Akintorinwa et al. (2012) stated that lateritic soil abounds locally and its use is mainly limited to civil engineering works like road construction and land fill operations. It is less utilized in the building industry except in filling works. Based on its abundance and availability, its optimum use in building production could positively affect the cost of buildings leading to the production of more affordable housing units (Joshua and Lawal, 2011).

Laterite can be used as a cheap, environment-friendly and readily available fine aggregate for block production, leading to reduction in the cost of blocks produced and building developments in Nigeria (Olugbenga et al., 2007). The focus of a good national development is to look inwards with intent to mobilize all natural resources for economic purposes (Ukpata et al., 2012).

II. MATERIALS AND METHODS

2.1 Materials

The study area for this research work took place at Soil/Concrete laboratory, Yaba College of Technology, Yaba, Lagos with latitude of 6.5095° N and longitude 3.3726° E. Dangote 3X cement and portable water were obtained from local vendor within the school premise. Laterite was sourced from Papalanto, Ogun State with 6.8861°N, 3.1955°E. Sand was obtained from Oju-elegba, Lagos State with 6.5096˚N and 3.3659˚E. These materials were carefully tested before their usage for the purpose of this research work.

2.2 Methods

2.2.1 Mix Proportion

The mix design adopted for this study is 1:6 with water cement ratio of 0.5. Sand was partially replaced with laterite at 10%, 20% and 30% respectively. Proportion of cement, sharp sand and laterite are represented in Table 1.

Table 1: Mixing proportion for hollow blocks

Ratio Content (%)	Cement (kg)	Sharp sand (kg)	Laterite (kg)	Water content (kg)
0	39.61	237.66	-	19.81
10	39.61	213.89	23.77	19.81
20	39.61	190.13	47.53	19.81
30	39.61	166.36	71.30	19.81

The proportion for interlocking bricks are represented Table 2.

Table 2: Mixing proportion for interlocking blocks

Ratio Content (%)	Cement (kg)	Sharp sand (kg)	Laterite (kg)	Water content (kg)
0	39.61	33.18	-	19.81
10	39.61	29.86	3.32	19.81
20	39.61	26.54	6.64	19.81
30	39.61	23.23	9.95	19.81

Fig 1: Mixing of hollow block materials for casting

2.2.2 Casting of Hollow and Interlocking Blocks
A prefabricated steel mould of 450mm x 225mm x 150mm and mould of 200mm x 100mm x 85mm were used for the production of the hollow and interlocking blocks respectively. Water was added in sufficient quantity to ensure workability of the mixture. The composite mixture was introduced into the mould and manually vibrated for one minute to ensure adequate compaction in accordance to BS 1377.

The freshly molded hollow and interlocking blocks on wooden pallets were carefully removed from the block moulds and placed on the clean, hard and flat ground surface for curing.

Fig 2: Removal of sand-crete hollow blocks on a clean surface

2.3 Method of Curing
The water sprinkling method of curing was adopted throughout the experiment daily. This process was carried out thrice in a day. For this study, curing was carried out for 7, 14, 21 and 28 days before subjecting them to water absorption, compressive strength and density tests.

III. RESULTS AND DISCUSSIONS

3.1 Results
The following tests carried out on hollow blocks and interlock bricks include:
a) Water absorption
b) Density
c) Compressive strength

3.1.1 Determination of Mechanical properties of hollow blocks and interlocking bricks

- Water absorption

The results of the average percentage water absorption of the hollow blocks produced at different percentage replacement are presented in Fig 3. The results presented below showed that the water absorption for all the hollow block samples at 10%, fell below the upper limit of 12% in accordance with BS 5628 Part 1. Hence, the blocks are recommended to be used in moist environment.

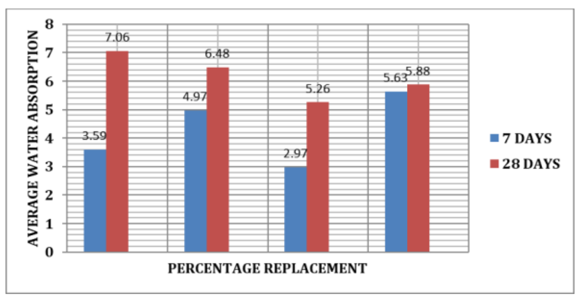

Fig 3: Summary of average water absorption values at 0-30% versus % replacement

- Density

Figure 4 and 5 showed that, generally, bulk densities and compressive strength of hollow blocks increases with increase in percent replacement of laterite. However, the early strength achieved at 7 day for 0% kept reducing as laterite percentage increases which affect the characteristics strength achieved at day 28 from 0-30% as the values decreases down the line. The average bulk density of the sand-crete blocks are below the NIS minimum standard of 2146kg/m^3. Interlocking bricks produced exceeds the NIS minimum standard of 1500kg/m^3. Hence, the sandcrete blocks produced are of lower quality which can be recommended for use as infill blocks in beam and block flooring while laterite bricks are recommended to construct residential building which requires no cement mortar as binding agent.

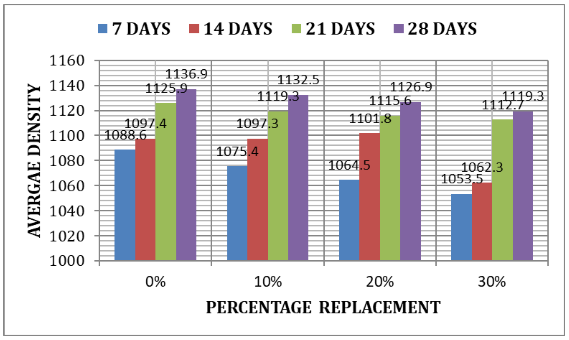

Fig 4: Summary of average densities values for hollow blocks versus % replacement

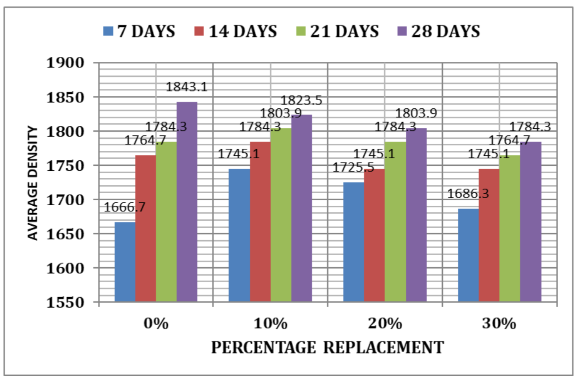

Fig 5: Summary of average densities values for interlocking bricks versus % replacement

- Compressive strength

The average compressive strength of the interlocking blocks varied from 1.45N/mm²-2.57N/mm² and 1.24N/mm² to 2.33N/mm² as the percentage replacement was increased from 0% to 30%, respectively. The compressive strength of interlocking bricks conforms to the standard specified by Nigeria Building and Road Research Institute (NBBRI, 2006).

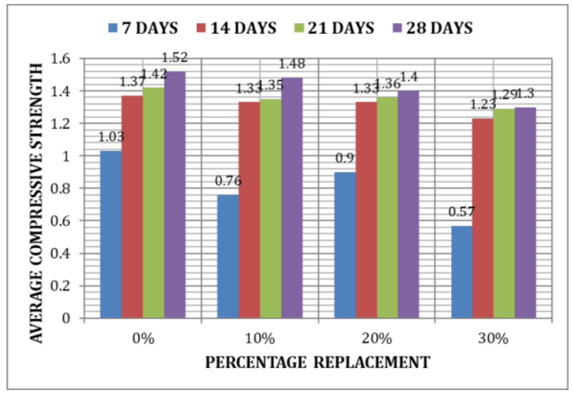

Figure 6: Summary of Average Compressive Strength Result of Hollow Blocks versus Percentage Replacement of Sharp Sand with Laterite

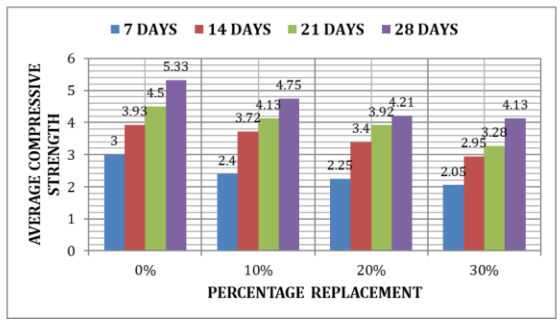

Figure 7: Summary of Average Compressive Strength Result of Interlocking Blocks versus Percentage Replacement of Sharp Sand with Laterite

CONCLUSION

Laterite was used as a partial replacement of fine aggregate at different percentage of 10%, 20% and 30% for the production of the hollow and interlocking blocks. The result revealed that hollow blocks produced were below the BS minimum standard for water absorption rate, density and compressive strength while interlocking blocks exceeds the NBBRI standard. Hence, hollow blocks can only be as non-load bearing walls while interlock bricks be improvised for construction for cost reduction of materials.

It was observed that the value for plasticity index of the laterite was zero because the plastic limit was greater than the liquid limit. Therefore, the degree of plasticity of the laterite used was non-plastic due to the presence of large number of silt present. Stabilization of laterite should be introduced to improve its properties in hollow and interlocking blocks.

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