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Optimization of the Compressive Strength of Sandcrete Blocks Produced by Progressive Replacement of Cement with Nano-Sized Laterite

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ABSTRACT

Many types of research have been done, and many are still ongoing in the novel and existing materials that will help in low-cost building to achieve the Sustainable Development Goal of providing houses even for low-income earners. This objective forms the nucleus of this research. In this study, the effects of partial replacement of cement with nano-sized laterite in the production of sandcrete blocks were studied. The aim was to determine the minimum quantity of laterite required to achieve adequate strength for walling units in buildings in partial replacement of cement in a mix of laterite-cement and to know the upper limit at which nanosized-laterite can be added to cement to produce a high-quality mix with maximum strength which will satisfy the minimum requirement for load-bearing walls. Six different mixes of laterite-cement at varying percentage of cement content were produced, moulded in block size and cured for 28 days. The variation was from 0 to 10% of the weight of cement at a constant interval of 2%. Two cubes were moulded for each mix, making a total of 12 blocks produced manually. It was found that the compressive strength of nano-sized laterite-cement mix is optimum when replacing 8% cement with nano-sized laterite.

1. INTRODUCTION

Majority of developing countries are today faced with an ever-increasing problem of providing adequate and yet affordable housing (Agbede and Manasseh, 2008; Kerali, 2010; Raheem et al., 2012; Ugwuanyi and Onuamah, 2018). In the last few decades, shelter conditions have been worsening and in particular: housing demand has risen due to the ever-increasing world population and the urgency to provide immediate practical solutions has become more pressing and demanding (Ogunsami et al., 2011; Joshua et al., 2014; Oyebisi et al., 2017).

In Nigeria, the commonest walling unit used in the construction of buildings is the sandcrete blocks. Sandcrete blocks are composite materials made up of cement, sand and water, moulded into different sizes. They are widely used as walling unit for partitioning and/or loading bearing in building structures (Offiong and Akpan, 2017; Oyebisi et al., 2017).

Lateritic soil possesses some properties which makes it potentially a very good and appropriate material for construction especially for the construction of rural structures in the developing countries (Oyenuga, 2001; Pai, 2016). Lateritic soils are one of the transported soils, which is essentially the products of weathering usually found in areas where natural drainage is impeded (Lasisi and Osunade, 1984; Amu et al., 2011). Its workability and plasticity in the presence of moist necessitates its use in lateralized sandcrete blocks production and for its use in other construction works, and lateralized concrete structures have potentially sufficient strength compared to that of normal concrete (Baiden and Tuuli, 2004; Abdullahi 2005; Anosike and Oyebade, 2012; Babatunde et al., 2015).

According to Asiedu and Agbenyega et al. (2012), lateritic soils abound locally and their use is mainly limited to civil engineering works like road construction (Jaritngam et al., 2012; Arinze et al. 2018) and landfill operations (Prakash and Poulose, 2014; Oni and Jimoh, 2016; Thankam et al., 2017). They are less utilized in the building industry except in filling works. Considering the abundance of lateritic soils and their availability, their optimum use in building production could positively affect the cost of buildings leading to the production of more affordable housing units (Aguwa, 2010; Okafor and Egbe 2017a; Okafor and Egbe 2017b). Its potentials and suitability in different areas of building construction needed for concerted research.

This study aimed at investigating the effects of partial replacement of cement with nanosized-lateritic soil in the production of sandcrete bricks. This is very important because of the exorbitant cost of Portland cement and desire by many countries to provide lowcost and yet relatively durable housings units for their populace.

2. MATERIALS AND METHODS

The materials used for this study include Dangote Ordinary Portland cement, laterite, river sand and water. The laterite samples were collected from Umuariaga Ikwuano, in Abia State, Nigeria and the river Sand was mined from Olokoro river also in Abia State. The pozzolanic laterite was crushed into fine particles afterwards sieved with the BS sieve 75 micron to have a fine powder. The sand was thoroughly screened, sieved and flushed with water to remove the deleterious substances to reduce the level of impurities and organic matter after which it was sun-dried, conforming to the requirements of (BS 882, 1982). Also, the collected sand was then spread on the floor to air dry after which the air-dried sample is then sieved through 10 mm BS test sieve to remove cobbles conforming to (BS 1377: Part 2-1990). The aggregate and the laterite were subjected to compressive tests. The lateritic sample prepared was saturated and subjected to cold centrifugation technique to make liquid nanoparticles to form. The saturated lateritic material was dried to obtain the desired powder. Solid sandcrete blocks were produced from sand, nano-laterite and cement. Two percent (2%) of the cement was replaced with the nano-lateritic and then 4%, 6% until the shear strength began to drop. Two blocks at each percentage replacement of cement aggregate with the lateritic soil content were produced, cured, weighed and tested for the twenty-eight (28) day compressive strength and the average values recoded. The first block was labeled A and second B. For control, two blocks were moulded without replacement, that is, with 100% conventional cement. They were prepared with uniform water/cement ratio of 0.6 to encourage maximum workability. These compressive strength values were compared with the 28-day strength requirements of a standard sandcrete block as specified in the National Building Code, NBC (2006).

3. RESULTS AND DISCUSSION

The results of the hardened sandcrete tests are given in the Tables 1 and 2. From table it is observed that the crushing load increased with the corresponding increase in the partial replacement up to 8% for each of the samples A and B. A significant drop in strength at 10% replacement was also observed. The drop in strength is likely because the quantity of laterite needed for adequate pozzolanic reaction has been exceeded (Abdullah et al., 2017). From Table 2, there is an observed significant increase in the strength of the sandcrete blocks from 0 to 8% with the highest compressive strength of 3.96 N/mm^2. There was also a decrease in the strength of the samples at 10% replacement. The least compressive strength (2.63 N/mm^2) was observed at 0% laterite. This shows that the nano-sized laterite enhanced the hydration reaction of cement with aggregates.

Table 1: Weight of the sample and the crushing load

Percentage replacement	Sample	Weight of sample (kg)	Force (kN)
0%	A	21.8	130
	B	21.5	165
2%	A	21.3	140
	B	22.1	200
4%	A	22.0	145
	B	22.7	200
6%	A	21.5	145
	B	22.3	210
8%	A	22.9	230
	B	22.5	215
10%	A	21.9	150
	B	21.8	145

Table 2: Compressive strength of the crushed samples

Percentage replacement	Average compressive
0%	2.62
2%	3.03
4%	3.07
6%	3.16
8%	3.96
10%	2.63

The sandcrete blocks experienced some significant difference for the various nanosized-laterite-cement mix from the results outlined in Tables 1 and 2 for both the crushing loads and the strength of the specimen respectively. The nanosized-laterite exhibited binding properties as shown by its ability to blend well with the fine aggregate and cement. However, the compressive strength of the blocks also met the minimum requirement of National Building Code (NBC) (2006) for manually compacted blocks used for load-bearing walls with the standard of 2.5 N/mm^2 strength. The increase in strength is likely to be because of the relatively high plasticity offered by laterite (Abdullah et al., 2017). Laterite are often well-graded soils. This points to the fact that it also contains silts and fine sands, so as the percentage of laterite increased, the percentage of these non-plastic silts and fine sands increases. This is likely the reason the strength started dropping at 10% laterite. A similar trend was observed by Aguwa (2010).

4. CONCLUSION

Since adequate strength for buildings was achieved with less cement content, it was concluded that the laterite-cement mix is an economical building material since the cost of blocks depends largely upon the cement content. It is highly recommended for adoption in the development of low-cost cost housing in developing countries since it found in great abundance in tropical countries.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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