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EFFECT OF DIFFERENT FINE AGGREGATES SOURCE ON THE COMPRESSIVE STRENGTH OF SANDCRETE HOLLOW BLOCKS

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Received: December 13, 2021 Accepted: February 20, 2022

Abstract Sandcrete blocks are produced from properly mixed constituents of cement, fine aggregate and water. Sandcrete blocks are used as both load and non – load bearing walls in the construction of buildings and structures in countries of the world. This study examined the compressive strength of sandcrete hollow blocks. The two different fine aggregates used for this study were sourced from Okhuaihe, and Ogheghe environs in Benin City, Edo State. The sandcrete blocks constituent materials were batched by weight and the sandcrete blocks were produced with mechanically vibrated block moulding machine using mix ratios of 1:6 and 1:8, respectively. A total of thirty six(36) sandcrete hollow block samples were tested for compressive strength at different curing periods of 7, 14, 21 and 28days respectively. The results of the 28days compressive strength of the sandcrete hollow blocks produced with the two fine aggregates, using cement/sand ratio of 1:6(water/cement ratio of 0.55) and also cement/sand ratio of 1:8(water/cement of 0.6) met the minimum compressive strength requirement of 1.75N/mm^2 and 2.76N/mm^2 as recommended by National Building Code and Nigerian Industrial Standard respectively. Based on the results, it is recommended that the two fine aggregates Okhuaihe sharp sand and Ogheghe erosion sand are suitable in sandcrete block production, also that there is need for sandcrete block producers to always have knowledge of the fine aggregate they intend to use and finally that relevant government agencies and other stakeholders to frequently organize trainings for stakeholders in the block industries on the need to adhere to standards.

Keywords**:** Batching method, Compressive Strength, Curing, Fine aggregates, **S**andcrete blocks.

Introduction

The Nigerian Industrial Standard (NIS: 87, 2004) described sandcrete block as constructional material comprising of cement, sand and water made into different sizes. British Standard (BS 6073: 1981 Part 2) gave the meaning of block to be building material, heterogeneous in nature with a unit larger size in all dimensions than specified for bricks with none of it dimension greater than 650mm and also its height not greater than its length. Sandcrete hollow blocks are material moulded from constituent materials; sand, cement in the proportion of 1:6, with appropriate amount of water, containing admixtures in some cases cured in a monitored environment (Hamisu and Mohammed, 2014). The various sizes of sandcrete blocks are; 225mm or (9 inches), 150 mm or (6 inches), 125 mm or (5 inches) and 10 mm or (4 inches) respectively (Alejo, 2020). The rectangular sandcrete block type can either be solid or hollow with 450mm × 150mm × 225mm and 450mm × 225mm × 225mm being the predominate dimensions respectively (Abdulwahab and Tunde, 2016).

It is also generally known that sandcrete blocks have become an integral component in building constructions in developing countries like Nigeria, Ghana, Togo, etc due to its usage as walls, and foundations etc, (Baiden, and Tuuli, 2004; Adekunle et al., 2018; Morenikeji et al., 2015; Osegbowa and Orie, 2019). Researches have shown that over 90% of building structures in Nigeria are constructed with sandcrete blocks (Anosike and Oyebade, 2012; Oladeji and Awos, 2013). Sandcrete Hollow blocks are mainly produced by the application of vibrating machines (Cisse and Laguerbe, 2000). It was stated by Abdullahi (2005) that the variation in quality of sandcrete blocks is due to the production method and the properties of the different constituent materials(cements, sands and water) used in sandcrete block production. The importance of sandcrete block as constructional material cannot be over emphasized as such appropriate measures should be taken during its production – as its quality can affect the quality outcome of construction. It was revealed by Oyekan and Kamiyo (2011) that sandcrete blocks are produced in many parts of Nigeria, without the producers making any reference to any code or stipulated standards.

Quality has been reported by Omopariola (2014) to mean the compliance to stipulated regulations or specifications. Commercial blocks manufacturers in Nigeria often reduce the quantity of cement below stipulated standard with a view to making more profits and minimizing production cost – which in turns affect the quality of produced sandcrete blocks (Okafor and Ewa, 2012). The collapse of buildings is attributed to poor qualities of construction materials(Anthony et al., 2015; Olusola and

Akintayo, 2009) and their consequences leading to loss of lives and damages of valuable possessions of people (Hilary, 2018). The compressive strength of sandcrete block is one of its main properties which is used to define the quality of sandcrete blocks and its depends on a lot of factors: properties of the constituent materials, curing periods, vibration period, sizes of the blocks, cavity volume and centre-web to end-web ratio etc, (Onwuka et al., 2013; Mahmoud et al., 2010; Omoregie, 2012; Ezeokonkwo, 2010; Ewa and Ukpata, 2013). In Nigeria, the National Building Code (NBC, 2006) and Nigerian Industrial Standard (NIS: 87, 2004), stipulated the minimum strength requirements for sandcrete blocks respectively. Odeyemi et al., (2015) concluded from their study that blocks that are manually compacted have lesser strength than those that are compacted with machines, and the strength of the blocks they used for their study met the requirements stated in the Nigeria Industrial standard.

Nevertheless the increase in population and industrialization has led to increased need for shelters(buildings and structures) which in turn has also led to increased need for constructional materials (cements, fine and coarse aggregates, water, etc). Sometimes the strike activities due to government policies and other occurrences of the lorry drivers association, who help in the transportation of fine aggregates from different sources to the needed location for block production and other uses, have also become a problem in this part of the world. These stated problems coupled with the state of the world economy has resulted in high cost of building materials(cement, fine aggregates etc.). In Nigeria most commercial sandcrete block producers and private individuals make use of fine aggregates(including erosion sands) from different sources in the production of sandcrete blocks without proper knowledge of the properties of the fine aggregates - which also conformed with Adekunle et al., (2018) findings. The motivation of this study is to assess the quality of sandcrete blocks produced with different sourced (Okhuaihe, and Ogheghe) fine aggregates in Benin City, Edo State and also to determine the fine aggregates suitability in the production of sandcrete blocks.

Materials and Methods

Materials

The fine aggregates(sand) used for this study were Okhuaihe sharp sand and Ogheghe erosion sand collected from Benin City, Edo State, Nigeria. The cement used for this study was Ordinary Portland Cement (OPC) grade 42.5, Dangote Brand purchased from Benin Metropolis in Edo State and it conformed to the requirements stipulated in BS EN 197–1: 2000 and NIS 444 - 1: 2003 respectively.

The water used for this work was potable water, obtained from a borehole tap and it was colourless, odourless, and tasteless, conforming to BS 3148, (1980).

Methods

Specific gravity and Particle size distribution Tests

Specific gravity and particle size distribution tests were conducted using the two fine aggregates. The specific gravity test was done in accordance with BS 812 – Part 2, (1995) and it was computed using equation 1, below.

$$\text{Specific gravity} = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)} \quad (1)$$

Where W_1 is the weight of an empty bottle, W_2 is the weight of bottle and soil sample, W_3 is the weight of the bottle, soil sample and distilled water and W_4 is the weight of bottle and distilled water.

While the particle size distribution test was carried on the fine aggregates in accordance with BS 812 – 103, (1985). The coefficient of curvature(Cc) and coefficient of uniformity(Cu) were obtained using equation 2 and equation 3 below.

$$\text{Coefficient of curvature(Cc)} = \frac{(D_{30})^2}{D_{60} X D_{10}} \quad (2)$$

$$\text{Coefficient of uniformity(Cu)} = \frac{D_{60}}{D_{10}} \quad (3)$$

Where D_{10}, D_{30} and D_{60} is the diameter of particles corresponding to 10%, 30% and 60% passing on the gradation curve.

Mix Proportions

It was reported by Osegbowa and Orie, (2019) that block industries in Nigeria averagely make use of water – cement ratio of 0.6 to 0.7, while sand - cement of 8.0. The National Building Code(NBC, 2006) recommended a cement/sand ratio of 1:6 for the production of sandcrete blocks. Based on these facts, 0.55 and 0.6, water - cement ratio, corresponding with 1:6 and 1:8, cement – sand ratios were used for this study.

Mix Proportions, Batching and Mixing

The fine aggregates (Okhuaihe sharp sand and Ogheghe erosion sand) were batched by weight in the proportions of water and cement ratios. The quantities by weight of the different constituents for the mixes were done using the average weights of 450mm x 225mm x 225mm blocks. The average weight of 450mm x 225mm x 225mm sandcrete block used was 23.50kg, with 15% addition to cover for any wastes and slump. The mix proportions by weight of the constituent materials are shown in Table 1. The mixing of the constituent materials(fine aggregates, cement and water) was done with

the help of a mixer for about 75seconds resulting to a uniform colour and consistent mixture used for the production of the 450mm x 225mm x 225mm sandcrete hollow blocks.

Table 1: Mix Ratios/Proportions

Mix Ratios			Mix Proportion(kg)		
Water/Cement	Cement	Sand	Water	Cement	Sand
0.55	1	6	1.97	3.58	21.48
0.60	1	8	1.65	2.78	22.06

Manufacture of the Sandcrete Hollow Blocks and Curing

The 450mm x 225mm x 225mm, sandcrete hollow blocks used for this study were moulded with mechanically vibrated block moulding machine with a mould of web 50mm which conforms to NIS 87: (2007) regulation. The moulding of the blocks was done by filling the metal mould in the moulding machine with the already mixed constituents followed by vibration for about 10seconds. A total of thirty six (36) sandcrete hollow blocks were moulded with the fine aggregate (Okhuaihe sharp sand and Ogheghe erosion sand). The sandcrete hollow blocks were stacked and cured in the laboratory by sprinkling water on them in the morning and in evening for three days - conforming to NIS: 87: (2004). The compressive strength test was carried for 7, 14, 21 and 28days respectively.

Compressive Strength Test

The crushing test was done with the sandcrete hollow blocks with the help of 2000KN capacity, compressive testing machine in accordance with BS EN 12390 – 3, (2002) for the different curing periods of 7, 14, 21 and 28days respectively. For more accurate results, two blocks were tested for each curing period, for a particular mix and for a particular fine aggregate. The compressive strength was obtained using the mathematical relationships shown in equation 4 with the dimension of the block loaded area as shown in figure 1.

$$\text{Crushing Strength} = \frac{Failure\ Load}{Loaded\ Area} \quad (4)$$

Where; Loaded area = (BL – 2ay), B = 225mm, L = 450mm, a = 125mm, and y = 150mm as shown in Figure 1.

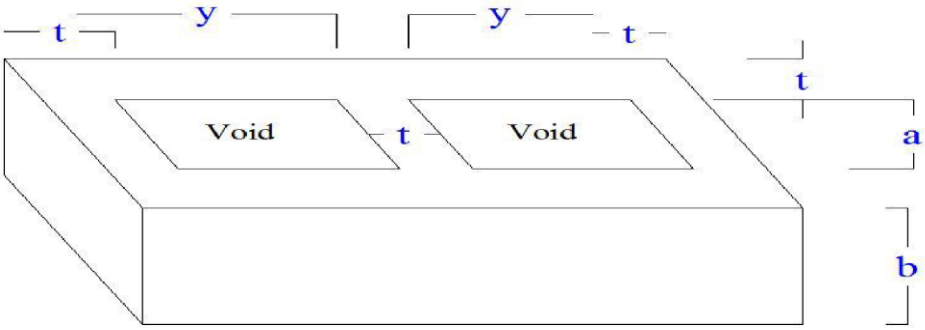

Fig. 1: The Sandcrete Hollow Block Mould Dimension

Results and Discussions

Specific gravity and Particle size distribution tests

The specific gravity of the fine aggregates(Okhuaihe sharp sand and Ogheghe erosion sand) used for the production of the sandcrete blocks are: 2.66 and 2.65 respectively. The results of the specific gravity for the two fine aggregates fall within the range; 2.30 – 2.90 suitable for sandcrete block production as stipulated by ACI Education Bulletin, (2007) and reported by Odeyemi et al., (2019).

The coefficient of uniformity and coefficient of curvature obtained from the particle size distribution for the two fine aggregates are shown in Table 2. The two fine aggregates were found to be well graded soils as they met the conditions ($Cu \geq 6$ and $1 < Cc \geq 3$) for well graded soils reported by (Tezaghi et al., 1996; Neville, 2011; Shetty, 2008).

Table 2: Coefficient of uniformity and Coefficient of curvature of the fine aggregates

S/N	Fine Aggregates	Coefficient of uniformity (Cu)	Coefficient of curvature (Cc)
1	Okhuaihe sharp sand	6.00	2.67
2	Ogheghe erosion sand	6.05	2.52

Compressive Strength of the Sandcrete Hollow Blocks

The average compressive strength results of the sandcrete hollow blocks made with the two fine aggregates for different curing periods(7, 14, 21, and 28days) are shown in Table 3. It was observed that there was increase in the compressive strength of the sandcrete hollow blocks made with the two fine aggregates with increase in cement contents and curing ages with the maximum values obtained at 28days. The reverse was the case with increase in the fine aggregates content. High strength of sandcrete blocks were obtained due to the fact that the blocks were produced with block vibrating machine which conformed with the finding of Odeyemi et al., (2015). The 28days compressive strength of the sandcrete hollow blocks made with the two fine aggregates with the use of cement/sand ratio of 1:6(as commended by NBC, 2006)[26] and water cement ratio of 0.55, met the minimum compressive strength requirement of 1.75N/mm^2 as commended by NBC (2006) and 2.76N/mm^2 as stipulated by NIS:87, (2004).

Table 3: Compressive Strength of the Sandcrete Hollow Blocks

Mix Ratio	Compressive Strength(N/mm^2) in days of sandcrete made with Okhuaihe Sharp Sand				Compressive Strength(N/mm^2) in days of sandcrete made with Ogheghe Erosion Sand			
	7 Days	14 Days	21 Days	28 Days	7 Days	14 Days	21 Days	28 Days
0.55:1:6	2.18	2.85	3.13	3.68	1.56	1.98	2.44	3.02
0.60:1:8	1.80	2.15	2.87	3.02	1.29	1.45	2.09	2.79

Conclusion

The study showed that the compressive strength of the sandcrete blocks made with the two fine aggregates (Okhuaihe sharp sand, and Ogheghe erosion sand) increased with reduction in the fine aggregates content and with increase in the cement content in the mix.The results of the 28days compressive strength of the sandcrete hollow blocks produced with the two fine aggregates, using cement/sand ratio of 1:6(water/cement ratio of 0.55), and cement/sand ratio of 1:8(water/cement of 0.6) met the minimum compressive strength requirement of 1.75N/mm2 and 2.76N/mm2 recommended by NBC, (2006) and NIS: 87, (2004) respectively. Findings from the study showed that the two fine aggregates Okhuaihe sharp sand and Ogheghe erosion sand obtained from Benin City are suitable in sandcrete block production. It is therefore necessary for sandcrete block producers to always have knowledge of the fine aggregate they intend to use in sandcrete block production and also for relevant government agencies and other stakeholders to frequently organize trainings, and webinars for stakeholders in the block industries on the need to adhere to standards.

Conflict of Interest

The authors declare that there is no conflict of interest reported in this study.

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