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ORIGINAL RESEARCH ARTICLE

IMPACT OF DIFFERENT FINE AGGREGATES ON THE COMPRESSIVE STRENGTH OF HOLLOW SANDCRETE BLOCKS

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ABSTRACT

Sandcrete blocks are walling materials that are made of fine aggregates and cement. Though, sandcrete blocks are being used as building materials in many parts of Nigeria, it has been discovered that many of the blocks produced do not conform to the minimum compressive strength requirement for such blocks. This study, therefore, examined the effect of using four (4) different fine aggregates (quarry dust, river sand, shocking sand and plastering sand) with binder to aggregate mix ratios of 1:6 and 1:4 on the compressive strength of sandcrete blocks. Specific gravity and particle size distribution analyses were conducted on the fine aggregates to determine their properties while water absorption capacity and compressive strength tests were carried out on the hollow sandcrete blocks. Five samples from each aggregate of size 450 mm x 225 mm x 225 mm were moulded and subjected to compressive strength tests. The water absorption capacity results revealed that shocking sand has the highest capacity to absorb water with a value of 8.69 %. River sand, with a value of 6.67 % has the lowest water absorption capacity. The 28th day compressive strength test results of 1.31 N/mm^2, 1.10 N/mm^2, 0.78 N/mm^2 and 0.50 N/mm^2 for the sandcrete blocks produced from quarry dust, river sand, shocking sand and plastering sand respectively, with mix ratio 1:6, did not meet the minimum requirement of 2.5 N/mm^2 specified by NIS 87:2007 for non-load bearing walls. However, with mix ratio of 1:4, the compressive strength of 2.52 N/mm^2 and 2.50 N/mm^2 for sandcrete blocks made with quarry dust and river sand respectively met this minimum requirement. It was concluded that only quarry dust and sharp sand at mix ratio 1:4 are suitable in the production of sandcrete blocks.

1.0 Introduction

Sandcrete blocks are composite walling materials moulded into different shapes and sizes that are composed of fine aggregate in addition with cement and water (NIS 87:2004, 2004). Ewa and Ukpata (2013) and Oyekan and Kamiyo (2011) described sandcrete hollow blocks as the most common masonry units in Nigeria. Nigeria Industrial standard (NIS 87:2000, 2000) reported that sandcrete blocks are formed either in solid or hollow rectangular shape. They are commonly found in 450 mm by 225 mm by 225 mm size for load bearing walls and 450 mm by 150 mm by 225 mm size for non-load bearing walls. Material constituents, mix proportion, admixtures presence, method of compaction and age of curing are significant factors that determine the mechanical properties of sandcrete blocks (Oyetola and Abdullahi, 2006; Anosike and Oyebade, 2012).

The high cost of materials used in the production of sandcrete blocks has contributed to an increase in the cost of building construction. Nair et al. (2006) posit that conventional building materials are beyond the reach of most of the world populace due to their poor affordability. However, the need for alternative materials for construction is very desirable for socio-economic development and materials that can complement cement at a cheaper rate will be of interest.

Though, sandcrete blocks are being used as building materials in many parts of Nigeria, it has been shown (Odeyemi et al., 2018) that many of the blocks produced do not conform with the minimum standard requirement for compressive strength value of 2.5 N/mm^2 and 3.45 N/mm^2 for non-load resisting wall and load resisting walls respectively as well as maximum specified 12 % water absorption recommended by Nigeria Industrial standard (NIS 87:2000, 2000).

The rate of building collapse in Nigeria building and development industry has been on the rise due to the use of substandard materials (Odeyemi et al., 2015). The durability of blocks depends on its quality, which in turn is greatly dependent on methods of production and properties of its constituents (Abdulwahab and Akinleye, 2016). Therefore, this study was aimed at investigating the degree to which different fine aggregates influence the compressive strengths of sandcrete blocks.

2. Materials and Methods

2.1 Materials

Dangote cement brands 42.5R, which conforms to NIS 444-1:2003 (2003), clean water, fine aggregates (river sand, quarry dust, plastering sand, and shocking sand) were used to produce the sandcrete block specimens. The river sand, quarry dust, plastering sand, and shocking sand were purchased from Danzaria Block factory, Ilorin in Kwara State, Nigeria.

2.2 Methods

Particle size distribution of the fine aggregates (quarry dust, river sand, shocking sand and plastering sand) was conducted in accordance with BS 812-103.1:1985 (1989). The percentage of the particles passing from the sieves was plotted against the particle diameters. From the graphs, the values of D_{60} and D_{10} were obtained. Equation (1) was adopted in calculating the Uniformity coefficient (Cu).

$$C_u = \frac{D_{60}}{D_{10}} \quad (1)$$

where: C_u is the Uniformity coefficient, D_{60} is the diameter of particle corresponding to 60% finer on the cumulative particle-size distribution curve and D_{10} is the diameter of particle corresponding to 10% finer on the cumulative particle-size distribution curve. If coefficient of uniformity (Cu) of soil < 4.0 then the soil is uniformly graded but if Cu > 4.0 then soil is could be well graded, or gap graded (Bowles, 1996; Neville, 2011; Shetty, 2008).

Specific gravity test was carried out on the aggregates in accordance with BS 1377-2 and ACI Education Bulletin. Equation (2) was used to calculate the specific gravity for each of the aggregates.

$$sg = \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)} \quad (2)$$

where: sg is the specific gravity, W_1 is the weight of empty bottle, W_2 is the weight of aggregate and bottle, W_3 is the weight of aggregate, bottle and distilled water, W_4 is the weight of bottle and distilled water.

The materials for the blocks were mixed manually using a shovel but vibrated mechanically using a sandcrete block moulding machine. A mix ratio of 1:6 (one portion of cement to six portions of sand) and 1:4 (one portion of cement to four portions of sand) was adopted respectively with water to cement ratio of 0.45, as specified by (NIS 87:2000, 2000), for manufacturing of sandcrete blocks in Nigeria and batching was done by weight.

Water absorption of a material is the ratio of the decrease in mass of that material to mass of its dry sample. It impacts on the bond between cement mortar and aggregates, the resistance of concrete to thawing and freezing, chemical stability and specific gravity (Anosike and Oyebade, 2012). The water absorption test carried out on the aggregates was done in accordance with (NIS 87:2000, 2000). In determining the water absorption for the aggregates, the samples were cleansed, drained and placed in a wire basket before immersing in distilled water for 24 hours at a temperature of 25°C. When removed from the water, the aggregates were air dried, weighed and designated as 'A'. Afterwards, the aggregates were placed in an oven for 24 hours at a temperature of 105 °C. When removed from the oven, it was cooled, weighed and designated as 'B'. The water absorption was calculated from Equation 3.

$$\text{Water Absorption } (\%) = \frac{A-B}{B} \times 100 \tag{3}$$

The sandcrete blocks were cured for 7 and 28 days by immersion in water and taken in batches for compressive strength determination at age 7 and 28 days respectively. Five blocks per case of observation were crushed at each maturing age and their crushing loads were recorded. The compressive strength test conducted on the sandcrete blocks was done in accordance with Nigeria Industrial standard (NIS 87:2000, 2000). A manual compression testing machine with a maximum load capacity of 1,560 kN from the Concrete Laboratory of the Department of Civil Engineering, University of Ilorin, Nigeria, was utilized for this test. The compressive strength of the sandcrete blocks in N/mm^2 was obtained by dividing the recorded crushing loads by the effective area of the blocks. The average compressive strengths for blocks produced from the four (4) aggregates considered were plotted at 7 and 28 days of curing.

A T-test statistical analysis was carried out to determine if there is a significant difference between the mean strength of the aggregates. A test of independence of the responses gotten was carried out using the following statement hypothesis:

H_0: The average compressive strengths are not significantly different from 2.5 N/mm^2

H_1: The average compressive strengths are significantly different from 2.5 N/mm^2

Significance level α: 0.05. The Decision Rule is 'Reject the Null Hypothesis H_0 if the P-value is less than the significance (0.05).'

3. Results and Discussion

3.1 Sieve Analysis Test

The results of the sieve analysis carried out on the four (4) types of aggregates are shown in Figures 1-4, while the corresponding coefficient of uniformity are shown in Table 1. The particle sizes of all the fine aggregates shown in Figures 1-4 were between 1 mm and 0.10 mm which means they fell within the category of medium sand and fine sand (Neville, 2011). From Table 1,

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all the aggregates have their values of C_u lower than 4.0. Thus, they are all classified as being uniformly graded (Bowles, 1996; Neville, 2011; Shetty, 2008).

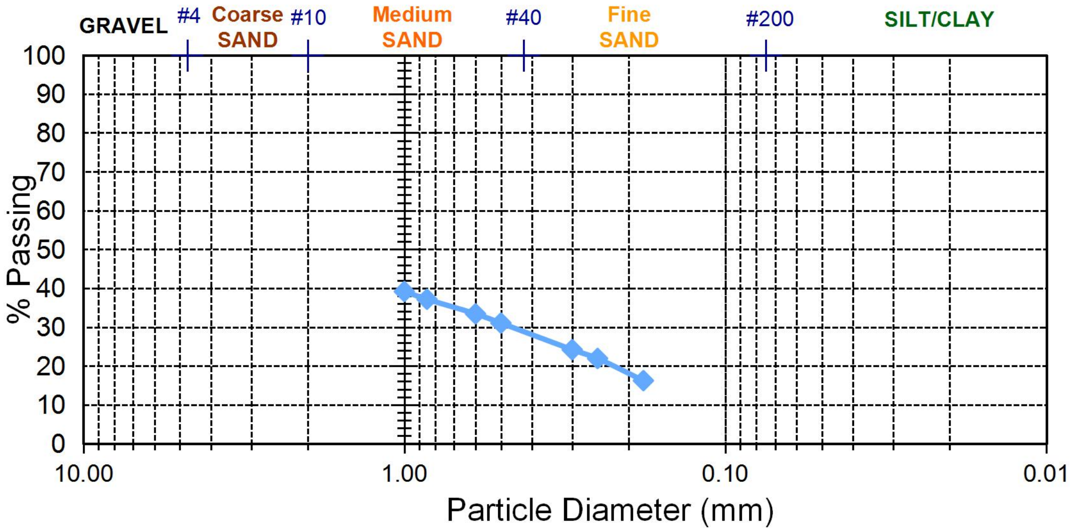

Figure 1: Particle Size Distribution of Quarry Dust

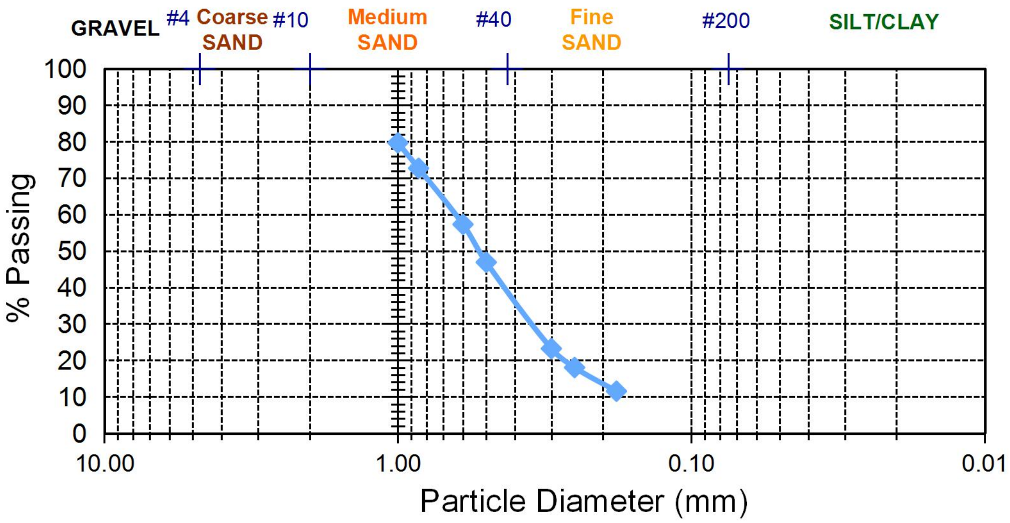

Figure 2: Particle Size Distribution of River Sand

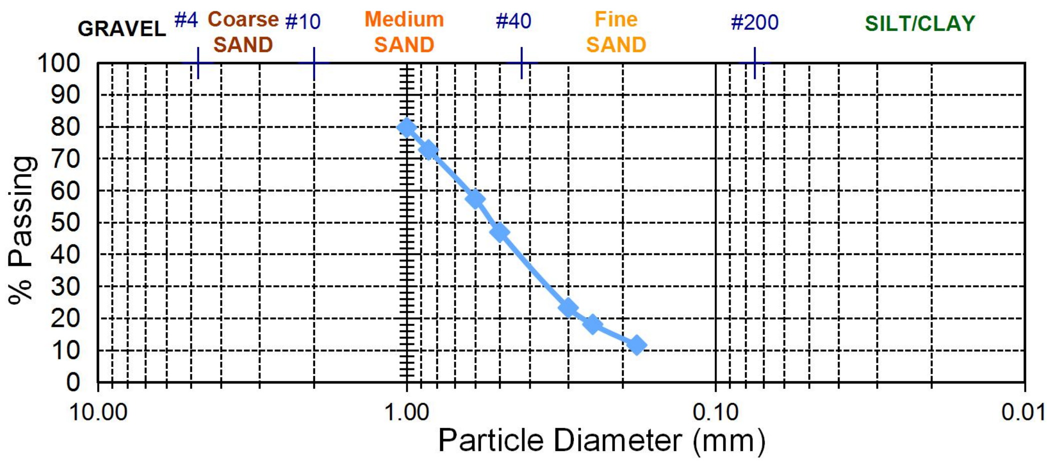

Figure 3: Particle Size Distribution of Shocking Sand

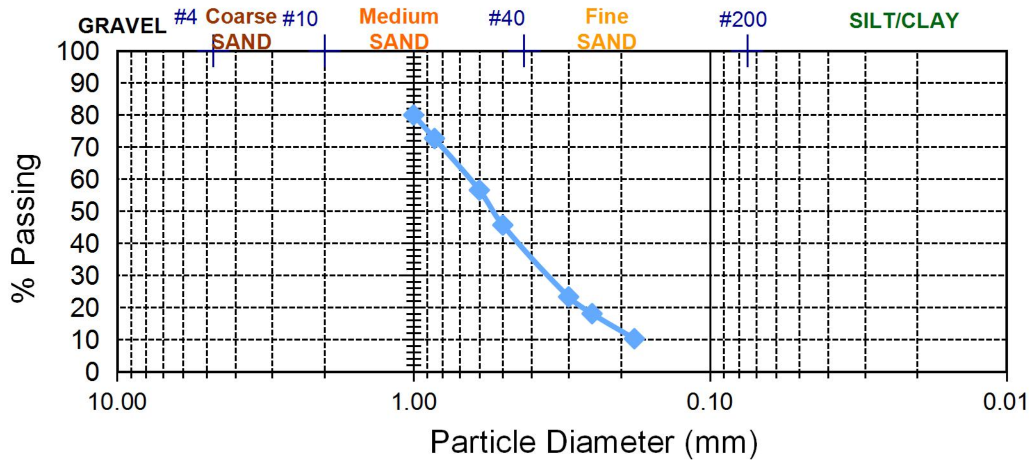

Figure 4: Particle Size Distribution of Plastering Sand

Table 1: Uniformity Coefficients for the samples

S/No	Soil sample	Uniformity Coefficient	Remark
1	Quarry Dust	1.5	Uniformly Graded
2	River Sand	2.5	Uniformly Graded
3	Shocking Sand	3.3	Uniformly Graded
4	Plastering Sand	3.3	Uniformly Graded

3.2 Specific Gravity Test

The specific gravity of the fine aggregates (quarry dust, river sand, shocking sand and plastering sand) used in this study are shown in Table 2. Specific gravity for aggregates, specified by (ACI Education Bulletin, 2007), ranged from 2.30 to 2.90. The results of the specific gravity of the quarry dust, river sand and shocking sand in Table 2 are within the acceptable limits for aggregates, while that of plastering sand is below the limit specified by the Standards. Thus, quarry dust, river sand and shocking sand can be considered as suitable aggregates for sandcrete block production based on their specific gravity.

Table 2: Specific Gravity of Fine Aggregates

Fine Aggregates	Specific Gravity
Quarry Dust	2.36
River Sand	2.61
Shocking Sand	2.39
Plastering Sand	2.29

3.3 Water Absorption Capacity Test

The result of the water absorption test carried out on the four (4) aggregates used in this study are shown in Figure 5. The water absorption rate result reveals that shocking sand has the highest capacity to absorb water with a value of 8.69 %. However, river sand, with a value of 6.67 %, has the lowest water absorption capacity. This implies that blocks made from shocking sand

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has a tendency of getting soaked earlier than blocks made from the other fine aggregates considered in the study.

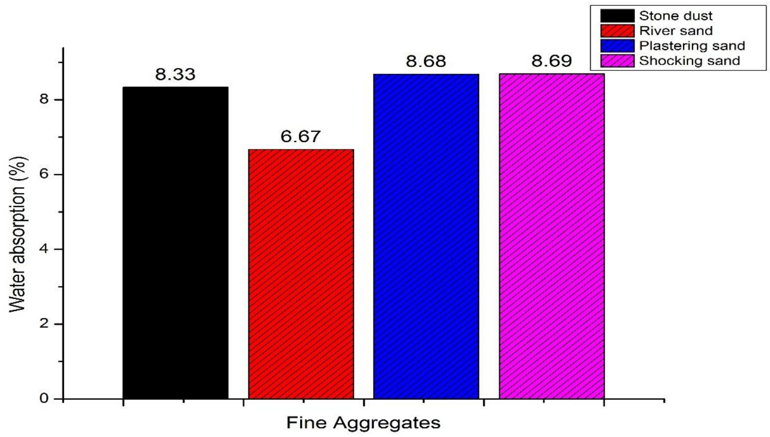

Figure 5: Water absorption Capacity for the fine aggregates

3.4 Compressive Strength Test

The compressive test results obtained for the sandcrete blocks produced with the four (4) aggregates considered in this study are shown in Figures 6 and 7 respectively.

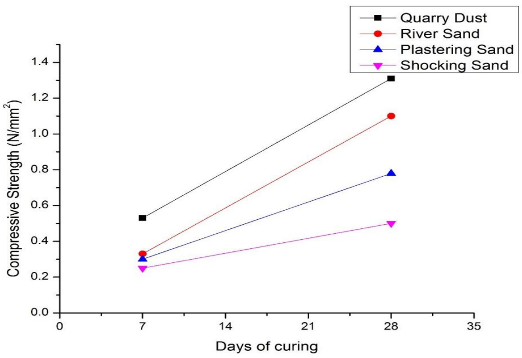

Figure 6: Average Compressive Strength for Mix Ratio 1:6

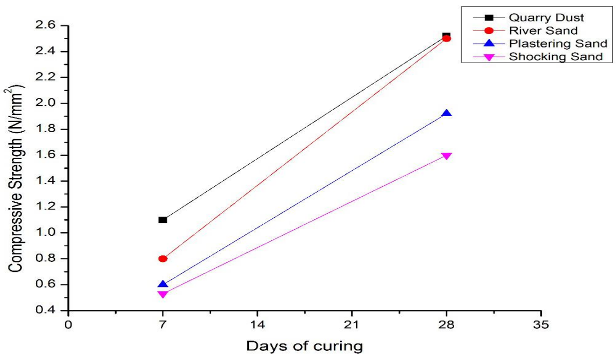

Figure 7: Average Compressive Strength for Mix Ratio 1:4

The results of the average compressive strength of sandcrete blocks with a mix ratio of 1:6 at 28th days of curing show that sandcrete blocks produced from quarry dust have the highest strength of 1.31 N/mm^2 followed by that of river sand (1.10 N/mm^2), shocking sand (0.50 N/mm^2) and plaster sand (0.78 N/mm^2). None of the strengths met the requirement of 2.5 N/mm^2 specified by Nigeria Industrial standard (NIS 87:2000, 2000). However, for mix ratio 1:4, the results showed that the compressive strength of sandcrete blocks made from quarry dust and river sand at 28 days met the requirement specified by Nigeria Industrial standard (NIS 87:2000, 2000) of 2.5 N/mm^2 for non-load bearing wall.

A T-Test statistical analysis was carried out on the results obtained for all the soil samples for both mix ratios 1:6 and 1:4 and the results are shown in Tables 3 and 4.

Table 3: T-Test for Average Compressive Strength of Sandcrete Blocks Produced with Mix ratio 1:6

Average Compressive Strength of Sandcrete Blocks Produce with 1:6	t	Degree of freedom	P-value
Quarry/stone dust	-11.303	5	.000
River sand	-20.431	5	.000
Plastering sand	-30.021	5	.000
Shocking sand	-29.336	5	.000

Table 4: T-Test for Average Compressive Strength of Sandcrete Blocks Produced with Mix ratio 1:4

Average Compressive Strength of Sandcrete Blocks Produce with 1:4	t	Degree of freedom	P-value
Quarry/stone dust	.351	3	.749
River sand	-.030	3	.978
Plastering sand	-14.189	3	.001
Shocking sand	-5.262	3	.013

From Table 3, the P-values (0.000) for the sandcrete blocks produced from the 4 soil samples with mix ratio 1:6 are less than the significance value (0.05). Thus, it is concluded that the average compressive strength of the sandcrete blocks are significantly different from 2.5 N/mm^2. From Table 4, the P-values for the sandcrete blocks produced with plastering and shocking sand (0.01 and 0.013) are less than significance value of 0.05, and the P-values for the sandcrete blocks produced with quarry dust and river sand (0.749 and 0.978) are greater than significance value of 0.05. Thus, it is concluded that the average compressive strength is not significantly different from 2.5 N/mm^2 for sandcrete blocks produced from quarry dust and river sand with mix ratio 1:4.

4. Conclusion

The following conclusion can be drawn from the study:

The compressive strength of hollow sandcrete blocks is dependent on the type of fine aggregate and mix ratios used in its production.

The coefficient of uniformity of the fine aggregates from particle size distribution shows that all the soils are uniformly graded.

Shocking sand has the highest capacity to absorb water with a value of 8.69 %. However, river sand, with a value of 6.67 %, has the lowest water absorption capacity.

The 28th day compressive strength results of sandcrete blocks produced with mix ratio 1:6 does not meet the required strength of 2.5 N/mm^2 for sandcrete blocks. However, with mix ratio 1:4 sandcrete blocks produced with quarry dust and river sand met this requirement.

It is recommended that only quarry dust and Sharp sand with mix ratios 1:4 are suitable for sandcrete block production.

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References

Abdulwahab, R. and Akinleye, TM. 2016. The effects of production methods on the compressive strength of hollow sandcrete blocks. Journal of Materials and Engineering Structures, 3: 197–204.

ACI Education Bulletin, 2007. Aggregates for Concrete-Materials for Concrete Construction. Developed by Committee E-701, American Concrete Institute, 38800 Country Club Dr, Farmington Hills, Michigan, United States.

Anosike, MN. and Oyebade, AA. 2012. Sandcrete Blocks and Quality Management in Nigeria Building Industry. Journal of Engineering, Project, and Production Management, 2(1): 37–46.

Bowles, JE. 1996. Foundation Analysis and Design, The McGraw-Hill Companies, Inc., N.Y.

BS 1377:2. 1990, 1996. Methods of Test for Soil for Civil Engineering Purposes. British Standards, BSI Group Headquarters 389 Chiswick High Road, London, W4 4AL, UK, Standards Policy and Strategy Committee.

BS 812-103.1:1985, 1989. Methods for Determination of Particle Size Distribution-Section 103.1 Sieve Tests.British Standards, BSI Group Headquarters 389 Chiswick High Road, London, W4 4AL, UK, Standards Policy and Strategy Committee.

Ewa, DE. and Ukpata, JO. 2013. Investigation of the Compressive Strengths of Commercial Sandcrete Blocks in Calabar Nigeria. International Journal of Engineering and Technology, 3(4): 477–482.

Neville, AM. 2011. Properties of Concrete. 5th ed., Pearson Education Ltd, London.

Nair, DG., Jagadish, KS. and Fraaij, A. 2006. Reactive pozzolanas from Rice Husk Ash: An Alternative to cement for rural housing. Cement and Concrete Research, 36: 1062–1071.

NIS 444-1:2003, 2003. Cement:- Pt. 1: Composition, specifications and conformity criteria for common cements. Nigerian Industrial Standard, Standard Organisation of Nigeria, Lagos, Nigeria.

NIS 87:2000, 2000. Standard for Sandcrete Blocks. Nigerian Industrial Standard, Standard Organisation of Nigeria, Lagos, Nigeria.

NIS 87:2004, 2004. Standard for Sandcrete Blocks in Nigeria.Nigerian Industrial Standard, Standard Organisation of Nigeria, Lagos, Nigeria.

Odeyemi, SO., Anifowose, MA., Oyeleke, MO., Adeyemi, AO. and Bakare, S.B. 2015. Effect of Calcium Chloride on the Compressive Strength of Concrete Produced from Three Brands of Nigerian Cement. American Journal of Civil Engineering (AJCE), 3(2–3): 1–5.

Odeyemi, SO., Akinpelu, MA., Atoyebi, OD. and Orire, KJ. 2018. Quality Assessment of Sandcrete Blocks Produced in Adeta, Kwara State, Nigeria. Nigerian Journal of Technology (NIJOTECH), 37(1): 53–59.

Oyekan, GL. and Kamiyo, OM. 2011. A Study on the Engineering Properties of Sandcrete Blocks Produced with Rice Husk Ash Blended Cement. Journal of Engineering and Technology Research, 3(3): 88–98.

Oyetola, EB. and Abdullahi, M. 2006. The use of rice husk ash in low-cost sandcrete block production. Leonardo Electronic Journal of Practices and Technologies, 8: 58–70.

Shetty, MS. 2008. Concrete Technology Theory and Practice. S. Chand and Company Ltd., New-Delhi, India