ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 07, Issue, 09, pp.14923-14928, September, 2017

ORIGINAL RESEARCH ARTICLE

OPEN ACCESS

EFFECT OF WATER-CEMENT RATIO ON THE COMPRESSIVE STRENGTH OF SANDCRETE BLOCK BLENDED WITH SAWDUST ASH

[1]Afolayan, J. O., [2]Ijimdia, S.T. and [1]Oriola F.O.P.

[1]Department of Civil Engineering, Nigerian Defence Academy, Kaduna, Nigeria
[2]Department of Civil Engineering, Ahmadu Bello University, Zaria, Nigeria

ARTICLE INFO

Article History:
Received 18th June, 2017
Received in revised form
19th July, 2017
Accepted 24th August, 2017
Published online 30th September, 2017

Key words:

Sandcrete Block,
Saw dust Ash,
Ordinary Portland cement,
Water Cement ratio,
Compressive Strength.

ABSTRACT

The problem of managing agricultural and industrial wastes has become a challenge in recent time. Therefore, research in the area of minimizing waste accumulation through reclamation and recycling has been ignited considering their aesthetic and ecological problems caused by the improper disposal. Areas of research aimed at reducing waste include the use of sawdust ash, rice-husk ash and groundnut-husk ash to partially replace cement in the production of concrete or sandcrete blocks. The use of sawdust ash (SDA) as replacement of cement in the production of sandcrete blocks was investigated. The aim was to determine the percentage of SDA and water-cement ratio that would give the 28-day maximum strength. The sawdust ash was used to partially replace Ordinary Portland Cement (OPC) in various proportions (0%, 5% 10%, 15% and 20%).Cubes were produced using mix ratio 1:4 and water-cement ratios of 0.40, 0.50, 0.55 and 0.60.The cubes were tested at the ages of 7, 14, 21 and 28 days for each proportion of OPC/SDA and water cement ratio. The results indicated that compressive strength of blocks at 28 days was 3.80N/mm^2 and 3.50N/mm^2 for 5% SDA at water-cement ratios 0.55 and 0.60 respectively. The compressive strength for 10% SDA was 2.87N/mm^2 and 3.10N/mm^2 at water-cement ratios 0.55 and 0.60 respectively. The 5% and 10% percentage replacements have compressive greater than the required strength of 2.00N/mm^2 specified by the Nigerian National Building Code (2006) for non-load bearing walls. By these results sandcrete blocks with up to 10% SDA replacement at water-cement ratios 0.55 and 0.60 can be used for non-load bearing walls.

***Corresponding author**

Citation: Afolayan, J. O., Ijimdia, S.T. and Oriola F.O.P. 2017. "Effect of Water-Cement Ratio on the Compressive Strength of Sandcrete Block Blended with Sawdust Ash".", *International Journal of Development Research*, 7, (09), 14923-14928.

INTRODUCTION

Shelter is a basic necessity of man after food and water. One of the major components of any kind of shelter is its walling material. The walling material is of different types, the Commonest in Nigeria being sandcrete hollow blocks. Seeley (1993) defines sandcrete blocks as walling materials that are made of coarse natural sand or crushed rock dust mixed with cement in certain proportion and water, and moderately compacted into shapes. On moulding they set, harden and attain adequate strength to be used as walling materials. Sandcrete hollow blocks may be either lightweight or dense. According to Itodo (1998), the density of sandcrete blocks ranges between 625kg/m^3 and 1,500kg/m^3 for light weight blocks and between 1,920kg/m^3 and 2,080kg/m^3 for dense blocks.

The strength of sandcrete blocks however are determined by its compressive strength which is a measure of their resistance to load application when placed in the crushing machine. BS2028 (1968) recommends 3.45N/mm^2 for the mean strength, and 2.59N/mm^2 for the lowest individual strength. The Federal Ministry of Works (1979) recommends 2.1N/mm^2 for mean strength and 1.7N/mm^2 for the lowest individual strength. The materials used for the production of sandcrete hollow blocks are cement, sand and water. Cement being the most costly material, its reduction will definitely reduce the cost of production of sandcrete hollow blocks and ultimately that of the building. Cement can be reduced by partially replacing it with a pozzolana. Since the introduction of cement in Nigeria in the 1950s, there has been a boom in the construction industry.

The use of alternative walling material to cement in its various forms continues alongside with the development of cement technology. With the down turn in the economy in the 1970s, cost consideration has been an important factor in the construction industry. The building and allied industries have shifted from the use of conventional construction materials to newer materials like fibre, reinforced plastics, aluminum, new varieties of bricks, cement, glass and steel due to economy enhanced in the use of these materials. Nigeria building and construction industry, like in many other developing countries, is exploring and combining materials within its vicinity so as to meet the ever increasing demand for shelter.

The choice and sustainability of a particular material depend largely on its availability, nature of project, durability, individual preference and economic consideration. In this research, saw dust ash (SDA) was used to partially replace ordinary Portland cement (OPC) in production of sandcrete hollow blocks. SDA is considered as pozzolana. Pozzolana is described as an artificial or a natural material containing silica in a reactive form. Generally, it is a siliceous and aluminous material which in itself possesses little or no cementious properties. However, it can react chemically with calcium hydroxide to form compounds possessing cementious properties when it is in finely divided form and in the presence of lime and moisture. The aim of this research is to assess the effect of water-cement ratio on compressive strength of sandcrete blocks blended with saw dust ash, to determine the chemical composition of sawdust ash to be used. To also determine the optimum sawdust ash replacement in sandcrete block.

MATERIALS AND METHODS

The materials used in this research were carefully selected and discussed below:

Materials

Sawdust Ash

The saw dust used for this study was collected manually from sawmill at Doka crescent Abakpa, Kaduna State, Nigeria. Samples were carefully collected to avoid mixing with sand by collecting the newly produced ones with shovel and packing into sand bags. It was sun dried for 2 days to aid the burning process. The samples collected were burnt into ashes by open burning at temperature of 600^0c in an open drum. The ash was then grounded after cooling and sieved through 75micro millimeter sieve. The chemical analysis was carried out at National Geosciences Research Laboratory, Barnawa, Kaduna. The chemical composition of the SDA is presented in Table 1

Fine Aggregate

The fine aggregates (river sand) with maximum size of 2.8mm, free of clay, loam, dirt and any organic or chemical matter, was used for this study, and this was obtained from a construction site in Nigerian Defence Academy, Kaduna.

Cement

The cement used in the concrete was an ordinary Portland cement manufactured by Dangote cement company. It was obtained from a certified local dealer to ensure recent supply and free from adultration. The oxide composition of the cement is as presented in Table 1.

Table 1. Oxide Composition of Saw Dust Ash and Cement

OXIDE	SDA %	OPC %
SiO_2	3.40	14.42
Al_2O_2	7.00	3.48
K_2O	15.3	-
Na_2O	1.84	0.00
CaO	34.09	73.05
MgO	2.36	1.30
TiO_2	0.48	0.21
MnO	0.18	0.03
Fe_2O_3	1.72	3.38
BaO	0.25	-
P_2O_5	0.66	-
SO_3	0.91	2.99
V_2O_5	0.01	-
CuO	0.03	-
ZnO	0.13	-
SrO	0.61	-
Br	0.01	-
Cr2O3	Nil	-
LOI	31.02	-

Water

The water used in this research was fresh, colourless, odourless and tasteless potable water that is free from organic matter of was used for mixing. It was obtained from the Civil Engineering departmental laboratory, Nigerian Defence Academy, Kaduna.

METHODS

Particles Size Distribution Analysis

Sieve analysis helps to deter mine the particle size distribution of the fine aggregate. The sieve analysis for the samples was conducted in accordance to BS 410 and S ISO 3310.The fine aggregate used was clean and dry naturally occurring sharp sand. The sieve analysis result is presented in Table 2.

Production of Sandcrete Cubes

The cubes were manufactured with the use of a vibrating block moulding machine with a double (50mm x 50mm x 50mm) mould. A mix proportion of 1:4 cement-sand ratio was used. Five levels of cement substitution with SDA (0%, 5%, 10%, 15%, and 20%) by volume. Four different Water-cement ratios (0.4, 0.5, 0.55 and 0.6) were used. Hand mixing was employed and the materials were turned over a number of times until a homogeneous mix with uniform colour and consistency was attained. The composite mixture was then introduce into the mould in the block moulding machine and the block was vibrated for one minute to ensure adequate compaction. The blocks were allowed to stay undisturbed for 24 hours and sprinkled with water for three days.

Testing

The density and Compressive strength test was carried out on the cubes. The cubes were tested at 7, 14, 21 and 28 days. Prior to the testing of the cubes they were taken out from the curing bed two hours before conducting the test, to make the cubes relatively dry or free from moisture. The weights of each cube were taken before being placed on the compression testing machine. The cubes were crushed and their corresponding failure loads recorded. The density and the compressive strength results with corresponding water cement ratios and the percentage replacement of SDA are shown in tables 3 to 9.

RESULTS AND DISCUSSION

Chemical Analysis of Saw Dust Ash

The Chemical composition of Saw Dust Ash (SDA) is shown in Table 1. The average percentage composition of SiO_2 + Al_2O_3 + Fe_2O_3 is 12.1. However, the Loss on ignition is 31.02. As reported by Jerath and Hanson (2007), SDA falls under the category of Class C fly ash since the Loss of ignition is greater than 6.

Sieve Analysis of Fine Aggregate

Figure 1 showed the grading of sharp sand used in the production of sandcrete cubes. It could be observed from the figure that the coefficient of uniformity (Cu) and coefficient of curvature (Cc) for the sharp sand are 2.50 and 0.76 respectively. Thus, the sand can be said to be well graded. The sharp sand meet the British Standard requirements for fine aggregates under the fine grading zone as specified in BS 882:1992 and therefore suitable for use in the production of sandcrete block.

Table 2. Fine Aggregate Sieve Analysis

SIEVE NO	BS SIEVE SIZE (mm)	WEIGHT RETAINED (g)	CUMMULATIVE WEIGTH RETAINED (g)	PERCENTAGE RETAINED %	TOTALPASSING (%)
4	4.75	0	0	0	100.0
8	2.00	26.0	26.0	5.2	94.80
14	1.18	44.0	70.0	14.0	86.0
30	500μm	142.0	212.0	42.4	57.6
36	425 μm	38.0	250.0	50.0	50.0
52	300 μm	102.0	352.0	70.4	29,6
72	212 μm	80.0	432	86.4	13.6
100	150 μm	57.0	489.0	97.8	2.2
200	75 μm	6.0	495.0	99.0	1.0
Above		5.0	500.0	100.0	0

Table 3. Density of cubes at various percentage replacement with w/c= 0.40

AGE (DAYS)	SDA REPLACEMENT				
	0%	5%	10%	15%	20%
	DENSITY OF CUBES (Kg/m^3)				
7	1784.0	1750.0	1721.0	1694.0	1660.0
14	1731.0	1641.0	1630.0	1625.0	1613.0
21	1690.0	1592.0	1584.0	1540.0	1509.0
28	1616.0	1576.0	1522.0	1476.0	1399.0

Table 4: Density of cubes at various percentage replacement with w/c= 0.50

AGE (DAYS)	SDA REPLACEMENT				
	0%	5%	10%	15%	20%
	DENSITY OF CUBES (Kg/m^3)				
7	1936.0	1761.0	1740.0	1701.0	1689.0
14	1880.0	1688.0	1632.0	1618.0	1593.0
21	1813.0	1642.0	1605.0	1585.0	1500.0
28	1792.0	1585.0	1548.0	1490.0	1420.0

Table 5: Density of cubes at various percentage replacement with w/c= 0.55

AGE (DAYS)	SDA REPLACEMENT				
	0%	5%	10%	15%	20%
	DENSITY OF CUBES (Kg/m^3)				
7	1978.0	1904.0	1819.0	1709.0	1687.0
14	1920.0	1863.0	1736.0	1645.0	1570.0
21	1914.0	1788.0	1728.0	1599.0	1525.0
28	1872.0	1660.0	1590.0	1488.0	1449.0

Table 6: Density of cubes at various percentage replacement with w/c= 0.60

AGE (DAYS)	SDA REPLACEMENT				
	0%	5%	10%	15%	20%
	DENSITY OF CUBES (Kg/m^3)				
7	1920.0	1911.0	1794.0	1660.0	1621.0
14	1888.0	1824.0	1682.0	1604.0	1560.0
21	1872.0	1794.0	1601.0	1577.0	1495.0
28	1689.0	1570.0	1516.0	1485.0	1320.0

Table 7: Compressive strength test results using water ratio 0.40

AGE OF CUBE (DAYS)	SDA PERCENTAGE %				
	0%	5%	10%	15%	20%
	COMPRESSIVE STRENGTH N/MM^2				
7	3.3	2.47	1.2	1	0.8
14	3.34	2.5	1.25	1.02	0.84
21	3.4	2.51	1.3	1.02	0.85
28	3.45	2.55	1.4	1.05	0.87

Table 8: Compressive strength test results using water ratio 0.50

AGE OF CUBE	SDA PERCENTAGE %				
	0%	5%	10%	15%	20%
	COMPRESSIVE STRENGTH N/mm^2				
7	3.30	2.50	1.57	1.13	0.9
14	3.41	2.54	1.60	1.20	0.93
21	3.60	2.65	1.61	1.23	0.98
28	3.80	2.90	1.70	1.40	1.00

Table 9: Compressive strength test results using water ratio 0.55

AGE OF CUBE	SDA PERCENTAGE %				
	0%	5%	10%	15%	20%
	COMPRESSIVE STRENGTH N/MM^2				
7	3.60	3.10	2.13	1.25	0.89
14	4.20	3.40	2.26	1.31	0.94
21	4.67	3.57	2.39	1.64	0.99
28	5.33	3.80	2.87	2.00	1.20

Table 10: Compressive strength test results using water ratio 0.60

AGE OF CUBE	SDA PERCENTAGE %				
	0%	5%	10%	15%	20%
	COMPRESSIVE STRENGTH N/MM^2				
7	3.00	2.73	1.93	1.30	0.90
14	3.59	3.20	2.53	1.33	0.96
21	3.67	3.27	2.93	1.45	1.10
28	4.00	3.50	3.10	1.90	1.30

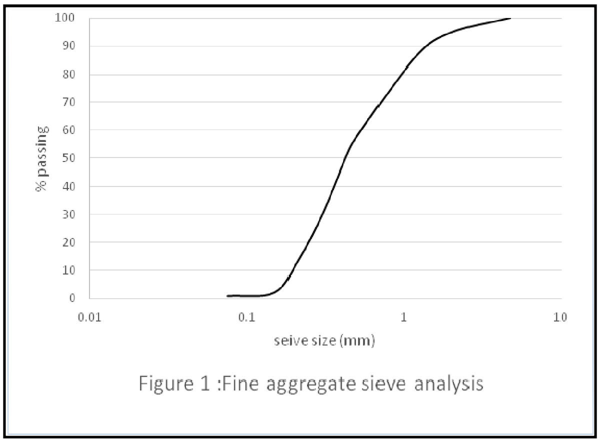


Figure 1 :Fine aggregate sieve analysis

Density of Sandcrete Cubes

The Density results are indicated in Tables 3 to Table 7. Generally, the results indicate decrease in density with increase in percentage of SDA substitution as shown in figures 2 to 5. The decrease in density with increase in SDA proportions accounts for loss in weight of the blocks due to increase in SDA. For all cases considered, the minimum density obtained was 1320.0kg/m^3 at 28 days for 20% SDA replacement and w/c= 0.6. Figure 4 shows the results of sandcrete cubes at w/c= 0.55 at different SDA replacement.

Figure 2: Density of cubes at diferent curing age with water cement ratio 0.4

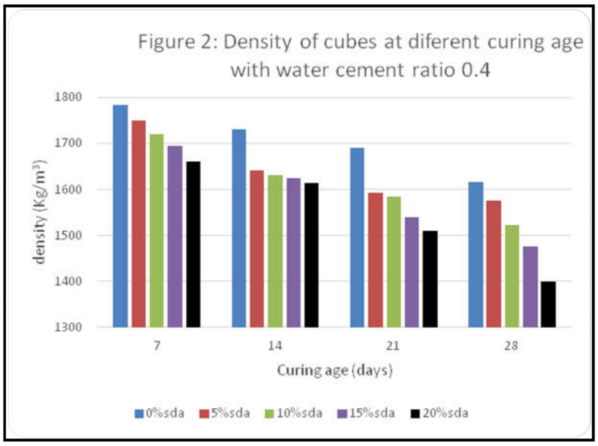


Figure 3 : Density of cubes at diferent curing age with water cement ratio 0.5

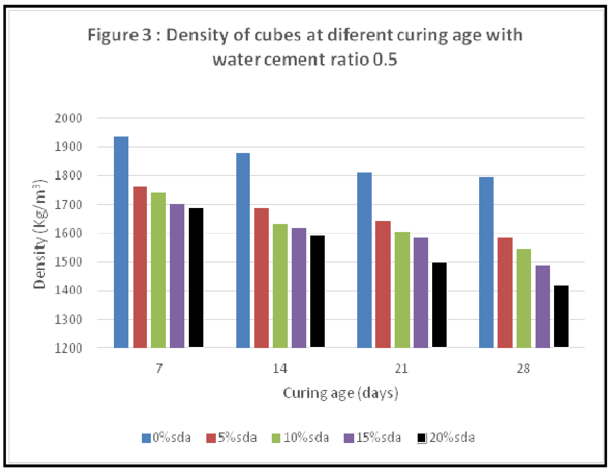


Figure 4: Density of cubes at diferent curing age with water cement ratio 0.55

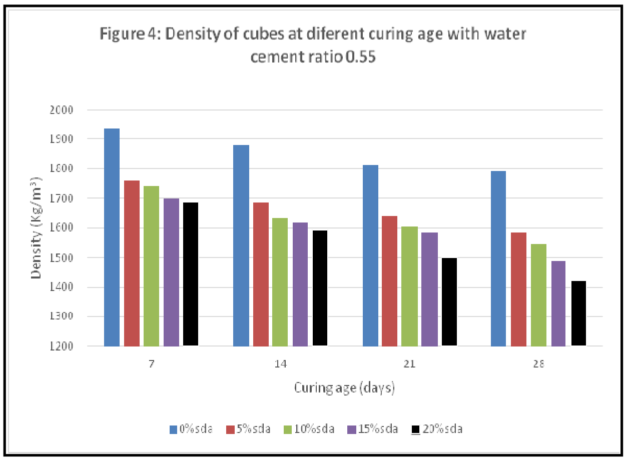
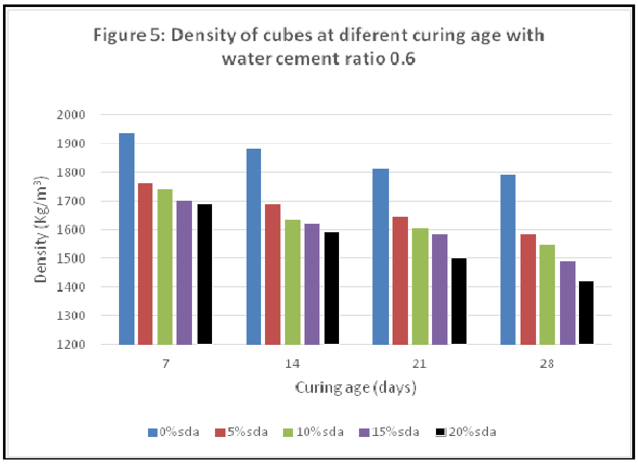


Figure 5: Density of cubes at diferent curing age with water cement ratio 0.6



The density ranges from 1978.0 kg/m^3 to 1872.0kg/m^3, 1914.0 kg/m^3 to 1660.0 kg/m^3 and 1819.0 kg/m^3 to 1590.0 kg/m^{3,} at

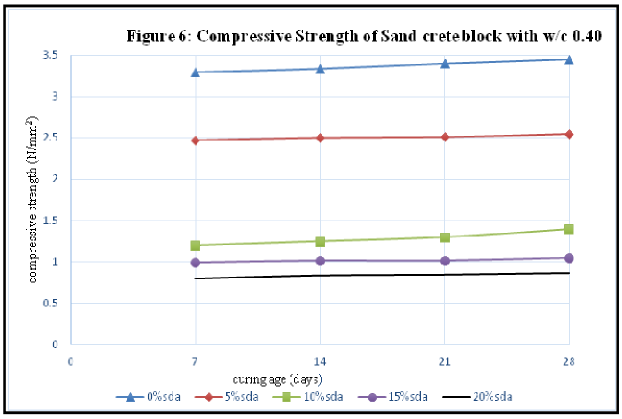


Figure 6: Compressive Strength of Sand crete block with w/c 0.40

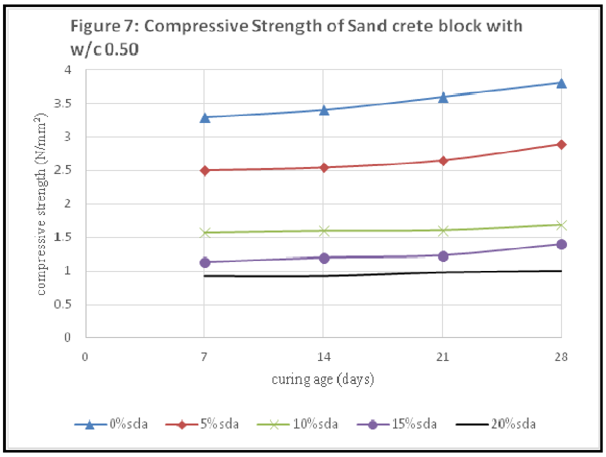


Figure 7: Compressive Strength of Sand crete block with w/c 0.50

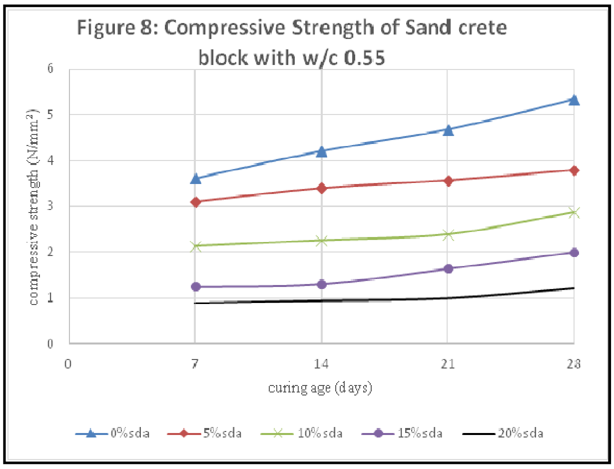


Figure 8: Compressive Strength of Sand crete block with w/c 0.55

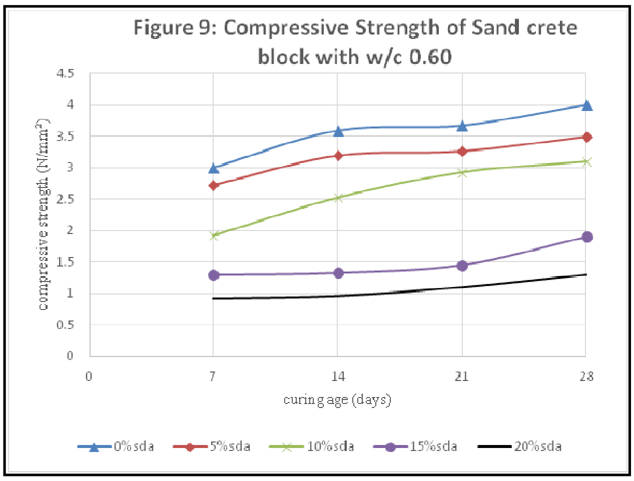


Figure 9: Compressive Strength of Sand crete block with w/c 0.60

0%, 5% and 10% SDA respectively. These values are lower than those of Raheem (2006) which range from 2073.5 kg/m^3 to 2166.3 kg/m^3. This may be due to differences in the physical properties of the sand used which depend on the source. However, the values were above the minimum value of 1500kg/m^3 recommended for first grade sandcrete blocks by NIS 087, (2000). The density results for 15% and 20% SDA replacement at w/c= 0.4, 0.5, 0.55 and 0.6 as shown in figures 2 to 5 followed the same trend with decrease in density as curing age increases. The densities were lower than that of the control, 5%, and 10% SDA contents but below the minimum value of 1500kg/m^3 recommended for first grade sandcrete blocks by NIS 087, (2000).

Compressive Strength result

The compression strength results are presented in tables 7 to 10, while figure 6-9 depicts the compressive strength development for the various water element ratio and the varying percentage of replacement of cement SDA. The compressive strength of 0.40 water cement ratio shows a decrease of strength as the percentage of SDA increases. However, at 5% SDA replacement the compressive strength of 2.55N/mm^2 satisfy the code requirement of 2.0N/mm^2 for non-load bearing specified by Nigerian National building code (2006). For the water cement ratio of 0.55 8hours appreciable strength development over w/c ratio 0.4.Although, decrease in strength was also observed at 20 days with 5% SDA replacement the compressive strength was 20% N/mm^2 which is 14% higher than that produced with 0.4w/c. Similarly, the compressive strength test results using water cement ratio 0.55 shows significant strength development above that of 0.40 and 0.50w/c. At 5% SDA replacement, 3.80 N/mm^2 compressive strength was obtained which is far above the recommended strength in for non load bearing The compressive strength development for adopting water cement ratio 0.60 shows a decrease in strength as the percentage of saw dust ash addition increases. The results, however shows that coater cement ratio 0.55 is the most adequate for the various percentage replacement of SDA in sandcrete blocks. The cement replacement with SDA in the percentage of 5% and 10% can produce sandcrete block of 3.8 N/mm^2 and 2.87 N/mm^2 comp resent at 28days of curing using mix ratio of 0.95% cement; 0.05 SDA and 4 s and.

Conclusion and Recommendations

Conclusion

Laboratory investigations were conducted and the results were analyzed to see the effect of water cement ratio on the sandcrete blocks blended with SDA. SDA has a fairly significant effect on the compressive strength of sandcrete blocks and its density. The weight of sandcrete blocks decreases as the saw dust ash content increases. The water cement ratio shows remarkable effect on the compressive strength as the w/c ratio increases up to 0.55 from 0.4 there are increases in the compressive strength of sandcrete blocks. It can be inferred from the investigation that sandcrete blocks containing SDA are suitable for use as non-load bearing blocks and that the addition of SDA into the sand – cement matrix can be used in the production of blocks with lighter weight.

Recommendation

It is recommended that:

- SDA can be used to partially replace cement in the production of sandcrete blocks.

- For a mix design of 1:4 and water cement ratios of 0.55 with 5%, 10% SDA should be employed for low income housing.
- For better strength, replacement of cement with SDA should be employed using a richer mix design.

REFERENCES

Adagba T, Tyagher S.T and Utsev J.T 2011. ''Suitability of sawdust ash-lime mixture for the production of sandcrete hollow blocks''. *Nigerian Journal of Technology*, vol. 30 No1 pp 79-84.

Anosike, M.N and Oyebade A.A 2011. "Sandcrete Blocks and Quality Management in Nigeria Building Industry", *Journal of Engineering, Project and Production Management*, 2(1), pp 37-46.

Anya U.C, Arimanwa J.I, Ettu L.O, Nwachukwu K.C and Okpara S.O 2013. ''Variation of OPC-Rice Husk Ash-Saw Dust Ash Composites Strength with Water- Cement Ratio, *International Journal of Engineering Research and Development* vol.8 pp 26-30

Akpen G.D, Tyagher S.T and Ogori P.O. 2005. Solid waste management in urban areas of Benue State. *International Journal of Environmental Issues*, Vol 3, No 2, pp5459.

British standards Institution: BS 2028, Part1: Specification for precast concrete blocks. Gayland and sons, 1968

Elinwa, A.U. and S.P. Ejeh, (2004) "Effects of the incorporation of sawdust waste incineration fly ash in cement pastes and mortars", J. Asian Archit. Build. Eng., 3, pp 1-7.

Ettu, L. O., Arimanwa, J. I., Njoku, F. C., Amanze, A. P. C., and Eziefula, U. G. 2013f. Strength of Blended Cement Sandcrete and Soilcrete Blocks Containing Sawdust Ash and Pawpaw Leaf Ash.*International Journal of Engineering Inventions* (IJEI), 2 (8): pp35-40.

Federal Ministry of Works Part 2. *Sandcrete block specifications* 1979.

Itodo E.O. Suitability of River Benue sand for sandcrete block production. University of Agriculture 1998.

National Building Code 2006. "*Building Regulations*", LexisNexis Butterworths, Ohio.

Raheem, A. A.; Momoh, A. K. and Shoyingbe, A. A. 2012. "Comparative Analysis of Sandcrete Hollow Blocks and Laterite Interlocking Blocks as Walling Elements",*International Journal of Sustainable Construction Engineering & Technology*, 3(1), pp 79– 88.

Raheem A.A and Sulaiman O.K (2013), ''Saw Dust Ash as Partial Replacement for Cement in the Production of Sandcrete Hollow blocks'', *International Journal of Engineering Research and Applications* vol.3 Issue 4 July-Aug 2013, pp 713-721.

Seeley I.H. ''Building Technology '' (4th Ed.). Macmillan Press 1993.

Shestoperov. ''Road and building materials''.1983.

Shetty, M.S. 2004. *Concrete Technology: Theory and Practical*. S. Chand and Company Ltd. Delhi, India.

Obam S.O and Tyagher S.T. Setting times, pozzolanicity of rice-husk ash cement and its concrete compressive strength relationship to water-cement ratio. *International Journal of Science and Technological Research* 2005, Vol 2, No 1 and 2, pp156 - 159.

Okunade, E.A. 2008. "*The effect of wood ash and sawdust admixtures on the engineering properties of a burnt laterite-clay brick.* J. Applied Sci., 8, pp 1042-1048.

****