

SUITABILITY OF SAW DUST ASH-LIME MIXTURE FOR PRODUCTION OF SANDCRETE HOLLOW BLOCKS

S.T. Tyagher^a, J.T. Utsev^{a,b}, T. Adagba^c

^aDEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF AGRICULTURE, MARKURDI, NIGERIA

^b(*Email: terlumunutsev@yahoo.co.uk*)

^cDEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF NIGERIA, NSUKKA, NIGERIA

Abstract

The use of saw-dust ash (SDA) mixed with 45% slaked lime for production of sandcrete hollow blocks was investigated. The aim was to determine the percentage SDA lime and water-cement ratio that would give the 28-day maximum strength. Saw dust was burnt and the ash sieved using a 150 micrometer sieve. The ash mixed with 45% slake lime was used to partially replace ordinary Portland cement (OPC) in various proportions. Fifteen blocks for each proportion were moulded using the mix of 1:8 and water-cement ratio of 0.50. Sprinkling of water on the blocks commenced after three days. The blocks were cured by complete immersion in water at room temperature. Three blocks were tested for strength at each of the ages of 7, 14 and 28 days for each proportion of OPC/SDA-lime. The 90:10 (cement: SDA-lime) proportion which gave the highest strength was further investigated for various water-cement ratios. It was concluded that for a mix of 1:8, 10% replacement of OPC by SDA-lime gave the maximum strength at water-cement ratio of 0.55 and was recommended for the production of sandcrete hollow blocks. The blocks should be used for low-income housing and non-load bearing walls.

Keywords: Sandcrete blocks, Saw-dust ash, Cement, Water-cement ratio, Strength

1. 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 [1] 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 light weight or dense. According to Itodo [2], the density of sandcrete blocks ranges between 625kg/m³ and 1,500kg/m³ for light weight blocks and between 1,920kg/m³ and

2,080kg/m³ for dense blocks.

Compressive strength of blocks is a measure of their resistance to load application when placed in the crushing machine. BS 2028 [3] recommends 3.45N/mm² for the mean strength, and 2.59N/mm² for the lowest individual strength. The Federal Ministry of Works [4] recommends 2.1N/mm² for mean strength and 1.7N/mm² for the lowest individual strength.

The cost of any building is the aggregate costs of its components. Similarly, the cost of any component of a building is the aggregate costs of its constituent materials. It therefore follows that the reduction in the cost of any material of a building component will lead to the corresponding decrease in the cost of the building.

The materials used for production of sandcrete hollow blocks are cement, sand and water. Cement is 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 [5].

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 [6]. Nigerias 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.

Due to the problem of managing waste, research in the area of minimizing waste accumulation through reclamation and recycling has been recently ignited considering aesthetic and ecological problems caused by the improper disposal of waste. Areas of research aimed at reducing waste include the use of rice-husk ash and groundnut-husk ash to produce cement [7 - 9].

In this research, saw dust ash (a pozzolana) was used to partially replace ordinary Portland cement in production of sandcrete hollow blocks. A pozzolana is 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 cementitious properties. However, it can react chemically with calcium hydroxide to form compounds possessing cementitious properties when it is in finely divided form and in the presence of lime and moisture [10, 11].

Obam and Tyagher [7] found out that partial replacement of OPC with rice-husk ash mixed with 45% slaked lime gave the maximum strength of concrete at water-cement ratio of 0.86. The aim of this research is to identify the water-cement ratio and the cement/SDA-lime proportion that will give the 28-day maximum compressive strength of sandcrete hollow blocks when OPC is partially replaced by SDA-lime mixture.

2. Saw-Dust Ash (SDA)

Saw dust is an organic waste resulting from the mechanical milling or processing of timber (wood) into various shapes and sizes. The

Table 1: Chemical Properties of SDA.

Constituents	% by weight
SiO ₂	67.95
AL ₂ O ₃	4.29
F ₂ O ₃	2.15
CaO	9.47
MgO	5.84
MnO	0.01
Na ₂ O	0.06
K ₂ O	0.11
P ₂ O ₅	0.46
SO ₃	0.56

dust is usually used as domestic fuel. The resulting ash known as saw-dust ash is a form of pozzolana. Saw dust is in abundance in Nigeria and other parts of the world. Chemical properties of SDA are presented in Table 1, and their comparison with other related materials is presented in Table 2.

3. Materials and Method

The materials used were saw-dust ash (SDA), slaked lime, ordinary Portland cement (OPC), sand and water. Saw dust was collected manually from the saw mill along Kashin Ibrahim road, Makurdi, Nigeria. The dust was burnt into ash by open burning using a drum. The SDA was sieved using 150 micrometer sieve. Slaked lime and OPC were obtained from retailer shops in Makurdi and transported to the Civil engineering laboratory, University of Agriculture, Makurdi. SDA was mixed with slaked lime in the ratio of 55:45. Sand (obtained from River Benue) was washed to remove any quantity of silt and clay. The average specific gravity of the sand was found to be 2.65.

SDA and lime were properly mixed to ensure uniformity. The proportion used for moulding the blocks was one part of cement or

Table 3: Pozzolanic activity index

Age (days)	SDA - lime Proportion			
	10%	20%	30%	40%
7	73.2	26.8	26.8	23.2
14	57.7	28.9	20.6	19.6
28	56.9	44.1	29.4	627.5

cement- SDA/lime to eight parts of sand (1:8). Water was added using a water-cement ratio of 0.50 and mixed thoroughly. The pozzolanic activity index of SDA-lime mixture was determined at the ages of 7, 14 and 28 days. The results are presented in Table 3.

Forty-five blocks of size 150mm ÷ 225mm ÷ 450mm were moulded and compacted mechanically, nine for each of the proportions of 100:0, 90:10, 80:20, 70:30 and 60:40 (cement: SDA-lime) by weight. The blocks were allowed to stay undisturbed for 24 hours and sprinkled with water for three days. They were then transferred to a tank containing water, cured by complete immersion and tested for density and strength at the ages of 7, 14 and 28 days. The density and strength results are presented in Tables 4 and 5 respectively.

The proportion of cement to SDA-lime (90:10) that gave the highest mean compressive strength at 28 days was further investigated using various water-cement ratios of 0.40, 0.45, 0.50, 0.55, 0.60. The results are presented in Figure 1.

4. Discussion of Results

Table 3 shows the pozzolanic activity index at various ages and proportions of SDA-lime. There is a decrease in the pozzolanic activity index with increase in SDA-lime proportion. The index does not have a discernible trend with the increase in the age of curing.

In Table 4, the density decreases with the increase in SDA-lime proportion and curing

Table 2: Comparison of SDA with other related materials *.

Constituents	SDA % by wt	Groundnut Husk ash % by wt	Rice husk ash % by wt	Bagasse Ash % by wt	Ordinary Portland cement % by wt
SiO ₂	67.95	54.03	93.10	73.00	20.70
AL ₂ O ₃	4.29	59.81	0.40	6.70	5.75
F ₂ O ₃	2.15	4.35	0.20	6.30	2.50
CaO	9.47	1.70	0.40	2.80	64.00
MgO	5.84	0.004	0.10	3.20	1.00
MnO	0.01	0.10	-	0.26	0.05
Na ₂ O	0.06	0.85	2.30	1.10	0.20
K ₂ O	0.11	0.17	-	2.40	0.60
P ₂ O ₅	0.46	1.44	-	2.09	0.15
SO ₃	0.56	0.09	2.80	-	2.75

* Source: Elinwa, A.U. and Awari, A. [8]

Table 4: Density at various ages.

Curing Age (days)	% SDA - lime				
	0%	10%	20%	30%	40%
	Density (Kg/m ³)				
7	2537	2427	2423	2414	2386
14	2486	2420	2413	2410	2353
28	2480	2408	2411	2389	2306

age. The decrease in density with increase in SDA-lime proportions accounts for loss in weight of the blocks due to increase in SDA-lime mixture.

In table 5, the decrease in strength with increase in SDA-lime proportion accounts for the light weight of SDA-lime mixture. The increase in strength with curing age accounts for more hydration of the SDA-lime/OPC paste in presence of moisture for a long time. The blocks become stronger when more SDA-lime/OPC paste is hydrated.

Figure 1 shows the strength development at various water-cement ratios using 90:10 cement to SDA-lime. The maximum mean compressive strength of 0.85 N/mm² occurs at

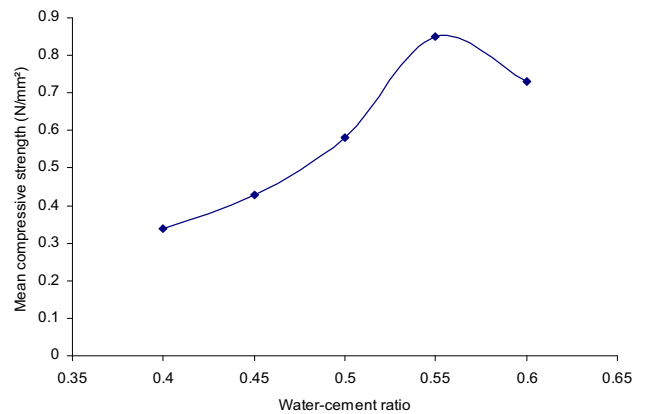


Figure 1: Compressive strength for various water-cement ratios using 90:10 (cement:SDA).

water-cement ratio of 0.55. Limitations exist in the data used in this paper as many vehicles find their way into the country through the activities of smugglers. However this does not preclude the fair analysis done in this work.

5. Conclusion and Recommendation

From the above investigations, it can be concluded that SDA has a fairly significant effect on the compressive strength of sandcrete

Table 5: Compressive strength ($w/c = 0.50$).

Curing Age (days)	Identification Mark	% SDA - lime				
		0%	10%	20%	30%	40%
		Compressive Strength (N/mm^2)				
7	P11	0.65	0.32	0.13	0.19	0.13
	P21	0.52	0.45	0.13	0.13	0.13
	P31	0.52	0.45	0.19	0.13	0.13
	Mean	0.56	0.41	0.15	0.15	0.13
14	P12	0.97	0.65	0.26	0.16	0.13
	P22	0.84	0.45	0.26	0.13	0.26
	P32	1.10	0.58	0.32	0.32	0.19
	Mean	0.97	0.56	0.28	0.20	0.19
28	P13	1.03	0.65	0.52	0.26	0.32
	P23	0.97	0.52	0.45	0.32	0.26
	P33	1.07	0.58	0.39	0.32	0.26
	Mean	1.02	0.58	0.45	0.30	0.28

blocks. As the percentage SDA content in the mix increased, the compressive strength of the sandcrete block decreased. It can also be inferred from the investigation that sandcrete blocks containing SDA are not strong enough to be used as load-bearing blocks but 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. About 10% replacement of cement by SDA for a mix design of 1:8 and a water cement ratio of 0.55 can be used. The results in table 5 do not meet the minimum strength of $2.1N/mm^2$ and the lowest strength of $1.7N/mm^2$ specified by the Federal Ministry of Works (1979). The highest pozzolanic activity index is 73.2%. From the results of the investigation, it can be recommended that:

- SDA can be used to partially replace cement in the production of sandcrete blocks.
- For a mix design of 1:8 and a water ce-

ment ratio of 0.55, only about 10% SDA should be employed.

- The blocks with 10% SDA should be used for low income housing.
- For better strength, replacement of cement with SDA should be employed using a richer mix design.

References

1. Seeley I.H. *Building Technology* (4th ed.). Macmillan Press 1993.
2. Itodo E.O. *Suitability of River Benue sand for sandcrete block production*. University of Agriculture 1998.
3. British standards Institution: *BS 2028, Part 1: Specification for precast concrete blocks*. Gayland and sons, 1968
4. Federal Ministry of Works Part 2. *Sandcrete block specifications* 1979.
5. Madedor A.O. *The impact of building materials research on low-cost housing development in Nigeria*. Nigerian Building and Road Research Institute 1992.

6. Shestoporov. *Road and building materials*. 1983.
7. 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.
8. Elinwa A.U and Awari A. Groundnut-husk ash concrete. *Nigerian Journal of Engineering Management* 2001, Vol 2, No 1, pp 8 - 15.
9. Akpen G.D, Tyagher S.T and Ogori P.O. Solid waste management in urban areas of Benue State. *International Journal of Environmental Issues* 2005, Vol 3, No 2, pp54 - 59.
10. Neville A.M. Pitman Publishing Limited 1996.
11. Aho, M. I. and Utsev J. T. Compressive Strength of Hollow Sandcrete Blocks made with Rice Husk Ash as partial replacement to Cement. *Nigerian Journal of Technology* 2008. Vol. 27 No. 2 ISSN 1115 8443. pp 71 - 77.