BREADFRUIT STEM ASH AS A PARTIAL REPLACEMENT OF CEMENT IN SANCRETE BLOCK MAKING.

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ABSTRACT

Sandcrete blocks are the most widely used materials for walling units in Nigeria. This study investigated the use of breadfruit stem ash (BFSA) as a partial replacement of cement in sandcrete block making. The breadfruit stem ash was burnt using a local burner and analysis was carried out on the chemical and physical properties of the ash. Four blocks each (150x150x150 mm) were cast at 0%, 5%, 10%, 20%, 25%, 30%, 40% and 50% replacement levels. The cubes were crushed at 7, 28, and 48 days of curing. The results show that the compressive strength varied from 1.5N/mm^2 to 6.5N/mm^2 for the replacement levels at 48 days of curing. The 50% to 20% replacement levels displayed very low compressive strengths which were between the ranges of 1.5N/mm^2 and 2.1N/mm^2. This is far below the specification of the Nigerian Industrial Standard (NIS) [12]. At the 0% replacement level, when there was no ash content, the compressive strength was observed to be 4.3N/mm^2, 5.8 N/mm^2, and 6.5 N/mm^2 respectively at 7days, 28days, and 48 days respectively. This is pretty above the minimum compressive strength as specified by the standard. Consequently, despite the fact that the BFSA possessed some compositions of pozzolans, it did not qualify for partial replacement of cement in sancrete at quantities above 10% of the binder.

Keywords: pozzolans, breadfruit stem ash, compressive strength, curing, sandcrete, partial replacement.

I. INTRODUCTION

Sandcrete is a yellow-white building material made from Portland cement and sand in a ratio of circa 1:8. It is similar but weaker than mortar for which the ratio is circa 1:5. Sandcrete is usually used as hollow rectangular blocks, often 45cm wide, 15cm tick, and 30cm hollows that run through from top to bottom and occupy around one third of the volume of the block. They are usually joined together with mortar. The final compressive strength of sandcrete can be as high as 4.6N/mm^2, which is much less than concrete's 40 N/mm^2. Sandcrete as a walling material has strength less than that of fired clay bricks, but sandcrete is considerably cheaper. Sandcrete is the major building material for walls of single storey buildings (such as schools and residential houses) in countries such as Nigeria and Ghana. Measured strengths of commercially available sandcrete blocks in Nigeria were found to be between 0.5 and 1 N/mm^2, which is well below the 3.5 N/mm^2 that is legally required. This may be due to the need of the manufacturers to keep the price low and since the main cost factor is the Portland cement, they reduce that which results in a block that starts behaving more like loose sand [14]. Attempts has been made towards increasing compressive strength by adding coarse aggregates, but since the cement content of sandcrete is small, the amount of water that is added to the mix to curer it will as well be little. Adding more solid materials makes the mix much less fluid, making it difficult to cast into blocks. Researches like this have been ongoing as investigations are being made into the use of organic ash to partially replace Portland cement. This is better than simply using less Portland cement. Such organic ashes that improve the strength characteristics of sandcretes and concretes are referred to as pozzolans.

A pozzolan is a silicious and aluminous material which, in itself, possesses little or no cementitious value but which will, in finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties[10]. This general definition of pozzolan embraces a large number of materials which vary widely in terms of origin, composition, and properties [14]. There are several materials, both natural and artificial, that are pozzolanic. These materials are used as supplementary cementitious materials. In other words, they are used as addition to Portland cement for concrete and sandcrete making as well as fort soil stabilization. Artificial pozzolans can be produced deliberately, for instance by thermal activation of kaolin-clays to obtain metakaolin, or can be obtained as waste or by-products from high temperature process such as fly ashes from coal-fired electricity production [14]. The most commonly used pozzolans are industrial by-products. Several of such by-products are agricultural wastes which are available in large but varying quantities. In Nigeria, rice husk ash, baggase ash, groundnut shell ash, among others has been confirmed to be credible pozzolans. Investigations are being made into the pozzolanic activities of other plant products of which the interest of this study is the breadfruit stem.

The varying importance of pozzolan utilization as partial replacement of cement in sandcrete and concrete cannot be overemphasized. There is much economy in the utilization of supposed wastes by converting them into useful materials in the building and construction industries. Besides, [1] rightly pointed out that most agricultural by-products in Nigeria are disposed in such a way that is environmentally unfriendly. [4] argued that disposal of wastes in a manner that is environmentally acceptable and avoiding the creation of some other forms of pollution which may generate hazard than is present in the original waste are the two most important objectives of modern solid waste management. More effective than the disposal of such wastes is their effective conversion and utilization.

Construction companies, especially those within Nigeria, make use of sandcrete blocks in most building constructions. Sandcrete blocks are used either as load bearing walls, partitions, or barriers. A sandcrete block must achieve a specified strength in order to be used for load bearing walls. The factors influencing the strength of sandcrete include; curing procedure, optimum moisture content, and the quality control [8]. The quality control is of key importance. Block industries, due to the high cost of cement, tend to producing substandard sandcrete blocks. This has resulted in many jeopardous occurrences. [11] reported the collapse of a building in Lagos in which the sandcrete blocks did not show sufficient hardness. The reason for reducing the standard is not farfetched. An average low income earner in a developing country like Nigeria desires to have a shelter over his head at the least possible cost. Oblivious of the consequences of building with substandard products, they patronize any product as long as it is the cheapest. The Engineer in such a situation must meet up with the quintessential responsibility of providing stable, durable, strong, but affordable products for the use of the fast growing population with low income.

Cement is the most expensive component of sandcrete blocks. It is the most important component since it is the binder. This most important component is, unfortunately, being compromised greatly by block makers. To arrest this menace, successful attempts have been made in the use of supplementary cementitious materials. [15] achieved a better compressive strength with concrete made with 30% replacement of cement with groundnut shell ash when compared with the control. The research conducted by [1] revealed a decreasing effect on the compressive strength of clay bricks and increasing water adsorption as groundnut shell ash increased. In a research conducted on fly ash, [13] elucidated the effects of partial replacement of cement with fly ash as; lowering the water demand of cement paste for similar workability, reduction in bleeding of the mix, decrease in the evolution of heat of hydration and increase in the setting time of the mix.

The African Breadfruit (*Treculia africana)* is found mostly in the southeastern part of Nigeria. The stem is milky grey softwood which is mostly used for fire making. The dry stem is very combustible, making it easy to be burnt by electric kiln or local process. Rice husks, baggase, and groundnut shell which many researchers have tested and confirmed are found mostly in the northern parts of Nigeria. Investigating into the pozolanic characteristics of some other materials like the breadfruit stem becomes very necessary, thus the purpose of this study.

II. MATERIALS AND METHODS

The breadfruit stem was collected from different locations around Awka metropolis. The wet stem was sawn into bits and properly sun dried. The local burner consisting of a drum with openings was used to burn the woods to ashes. The ash after cooling was sent to PRODA chemical laboratory in Enugu, Nigeria for chemical analysis and characterization which was carried out in accordance to [3].

The sand used for the study was a river bed sand from the dredge sand of river Niger in Onitsha, Anambra state of Nigeria. The Silt content and particle sand distribution of the sand was determined in accordance to [7]. Different mixes were made at 0%, 20%, and 40% replacement of cement with the Breadfruit stem ash. The Dangote brand of Portland cement was used for this research. The normal binder/sand ratio of 1:8 was adopted. The fresh sandcrete was placed in 150x150mm moulds. The tampering was done manually. Demoulding was after twenty four hours. The sprinkling method of curing was adopted in accordance with [12] and compressive strengths of the blocks were tested in accordance to [5] and [6].

III. RESULTS AND DISCUSSION

Ash Characterization

Table 1 shows the physical and chemical characteristics of the breadfruit stem ash in comparison with the ordinary Portland cement. The strength development of sandcrete blocks is as a result of the reaction between silica oxide (SiO_2) and lime (CaO) in the presence of moisture to form calcium silicate hydrate C-S-H [14]. The silica content of the breadfruit stem ash is very high but it has a very minute lime content of 1.19%. The approximate ratio of silica oxide to lime in the Portland cement is 1:3 while that of the breadfruit stem ash is 72:1. This shows obviously excessive silica content in the ash which in turn would result in unbalanced chemical reactions that will affect the adequate development of the binder microstructure. The pH of the ash was found to be 9.22 which indicates that the ash is basic. The ranges of SiO_2 content for different pH ranges have been specified thus: - Intermediate (52-66 wt %); acidic (>66 wt %); basic (45-52 wt %) and ultrabasic (<45 wt %) [14]. The excessively high silica content of 85.8% would make one to expect a poor characteristic strength performance.

Table 1- Comparison of ash characterization test results with Ordinary Portland Cement.

Constituent	Portland Cement %	Breadfruit stem ash %
SiO_2	20.70	85.80
Al_2O_3	5.75	1.27
Fe_2O_3	2.50	0.25
CaO	64.00	1.19
MgO	1.00	0.35
MnO	0.05	0.19
Na_2O	0.20	-
K_2O	0.60	-
P_2O_3	0.15	-
SO_3	2.75	-
C	-	21.00

IV. Moisture Content

Table 2 shows the calculation of the moisture content of the river bed sand used. The average percentage moisture content of 1.25% is so low that the moisture content of the sand is negligible in the batching and will not have any significant effect on the water content of the fresh sandcrete.

Table 2- Moisture Content Test Result for fine Aggregate.

Pan no.	W_1	W_2	W_3	W_2-W_3	W_1-W_2	% Moisture Content	Average% Moisture Content
1	108.4	107.3	18.3	89.0	1.15	1.29	
2	110.0	109.0	18.7	90.3	1.00	1.12	1.25
3	94.0	93.0	18.7	74.3	1.00	1.35	

Where W_1=Weight of pan + Wet Soil; W_2= Weight of pan + dry Soil; W_3= Weight of pan; W_1- W_2= Weight of Moisture; $W_2 - W_3$= Weight of dry Soil.

V. Particle Size Distribution

The sieve analysis carried out on the fine aggregate (river bed sand) used is displayed in figure 1. The distribution was done in accordance with the guidelines specified by [16]. As can be seen from the graph, the minimum and maximum grain sizes of the sand are 0.06mm and 3mm respectively. This corresponds to the ranges for sand.

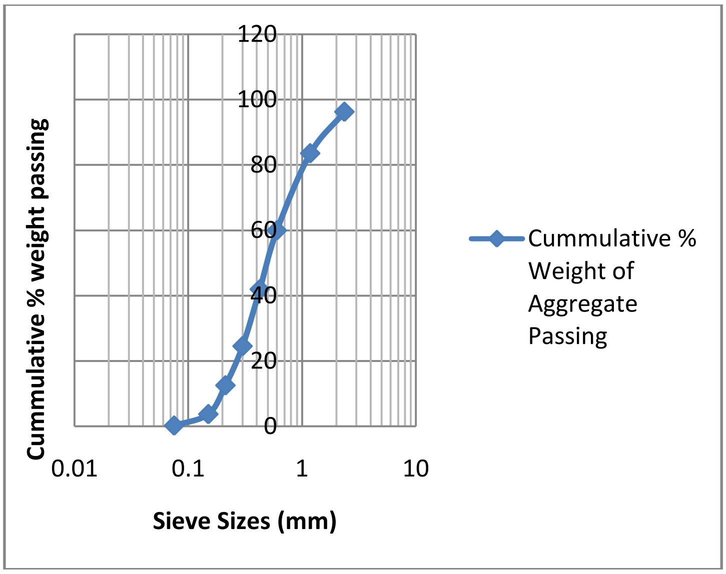

Figure 1: Particle Size Distribution of the fine aggregate

VI. Compressive Strength

Table 3 as well as figures 2a and 2b reveals the result of the compressive strength test. The compressive strength of the blocks generally incre ased with age at curing and decreased with increased breadfruit stem ash content. Apart from the control, with 0% replacement, the replacements up to 10% met the specified minimum standard of 3.5N/mm^2 according to [12]. There was a serious drop in strength of sandcrete with the addition of the breadfruit stem ash even as low as 20% replacement level. Even at long curing period up to 48 days, the 20% to 50% replacement levels yielded compressive strengths from 1.5 N/mm^2 to 2.1 N/mm^2 which are yet pretty below the standard. This poor performance would be due to the inadequate development of the binder microstructure as a result of unbalanced proportion of the constituent elements of the breadfruit stem ash as discussed earlier. It was also observed that the 28 day strengths of 1.5 N/mm^2 to 1.9 N/mm^2 achieved by those replacements from 40% to 20% are still better than the strengths of most marketed blocks within Nigeria that were made by simple reduction in cement quantity.

Table 3- Averaged Result of Compressive Strength of Sandcrete blocks cast with Partial Replacement of Cement with BFSA.

S/N	% BFSA	7 days (N/mm^2)	28 days (N/mm^2)	48 days (N/mm^2)
1	0%	4.3	5.8	6.5
2	5%	3.5	4.4	5.4
3	10%	2.8	3.5	4.5
4	20%	1.7	1.9	2.1
5	25%	1.4	1.7	1.9
6	30%	1.3	1.6	1.8
7	40%	1.2	1.5	1.7
8	50%	1.0	1.3	1.5

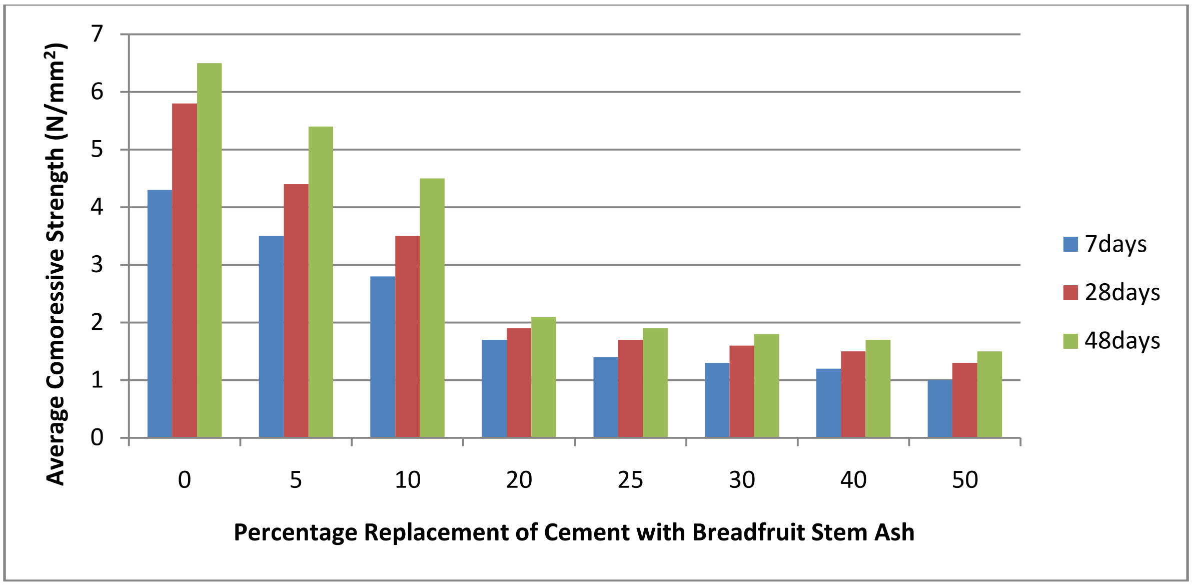

Figure 2a- Variation in Average Compressive Strength of Sandcrete blocks with quantity of BFSA and age a Curing.

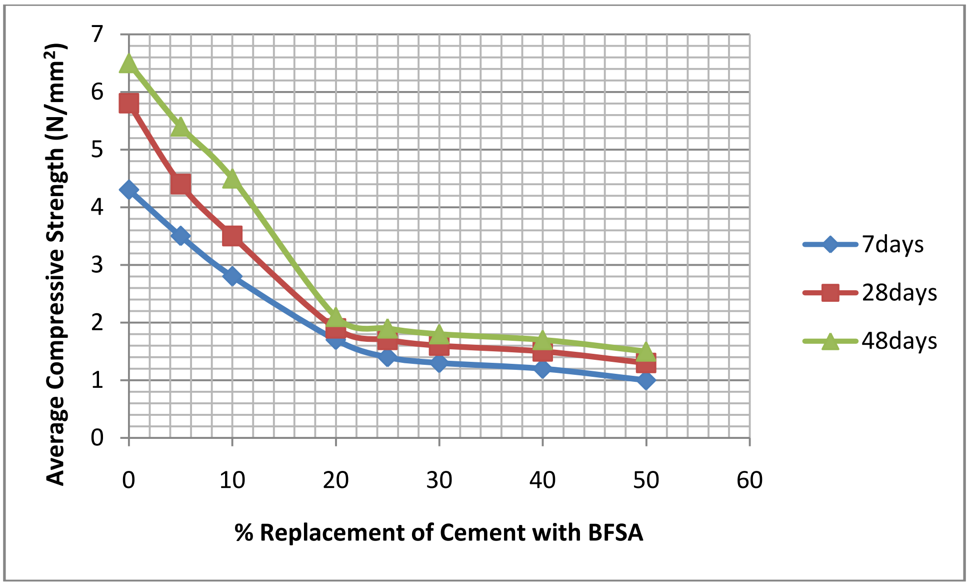

Figure 2b- Variation in Average Compressive Strength of Sandcrete blocks with quantity of BFSA and age a Curing.

VII. CONCLUSION AND RECOMMENDATIONS

From the foregone analysis, sandcretes made with partial replacement of cement with breadfruit stem ash beyond 10% yielded very low compressive strengths, even at 48 days of curing, than the specified strength. Sequel to these observations, it could be concluded that the breadfruit stem ash cannot be used as a partial replacement of cement in sandcrete block making at such large quantities. Hence the following recommendations were made;

1. Sandcrete block makers (local and industrial) should be encouraged to make use of breadfruit stem ash as a partial replacement of the sandcrete binder up to 10% and be dissuaded of using mixes that are poorer than 1:8.
2. Further research works should be carried out, especially in the effect of the production process of the ash on its pozzolanic activity. Electric kiln should be used instead of the local burner and investigations made should there be any improvement in the performance of the ash.
3. The research should as well be extended to the use of breadfruit stem ash in concrete.

4. The government should provide special grants for funding researches in the area of building and construction with safer and more economical materials.

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