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Effect of Sheanut Shell Ash as A Partial Replacement Of Ordinary Portland Cement In Mortar

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ABSTRACT: The study examines and presents the possibility of using Shea-nut Shell Ash (SSA) as a partial replacement of cement for mortar production in construction work. This was appraised through laboratory test conducted. The chemical test conducted revealed that Shea-nut Shell possessed pozzolanic properties, and mortar cube measuring 50mm x 50mm x 50mm were cast using a mix ratio of 1:6 (cement/fine aggregate) and water/binder-cement-SSA ratio of 0.6 was prepared by using SSA to replace 0%, 5%, 10%, 15% and 20% of ordinary Portland cement. A total of 60 cubes were cast and cured in water for 7, 14, 21 and 28 days respectively. Properties such as compressive strength, setting time and density increased as the percentage of SSA increases. The SSA mortar gave the highest compressive strength for 0-20% replacement at 28 days curing as 4.5N/mm^2 for 0%, 3.25 N/mm^2 for 5%, 3.05 N/mm^2 for 10%, 2.61 N/mm^2 for 15% and 2.05 N/mm^2 for 20%. Shea-nut Shell Ash (SSA) can be effectively use in masonry and production of sandcrete blocks.

KEYWORD: Shea-nut Shell, mortar, pozzolana, setting time, compressive strength

I. INTRODUCTION

In view of the environmental and sustainability concerns associated with the production of cement, the use of Pozzolana to replace part of Portland clinker either partially or entirely is also being investigated as an alternative to carbon dioxide emissions. Up to 70% of Portland cement can be replace by using materials such as primarily fly ash, slag, silica fume, natural Pozzolana, rice-husk ash, wood ash, and agricultural product ash (Osei and Jackson, 2012).Portland cement is the most common type of cement used in construction applications, but it is an expensive binder due to the high cost of production associated with the high energy requirements of the manufacturing process itself. (Neville 1995), in addition to reduce cost of binder, there are potential technological benefits from the use of Pozzolana material as those blended with Portland cement in concrete applications.

Benefits of Pozzolana

Several benefits of Pozzolana has been investigated and these include increased workability, decreased permeability (Ghrici et al 2007), increased resistance to sulphate attack (Bunici and Aksoga 2006), improved resistance to thermal cracking and increased strength and durability of concrete (Papadakis and Tsimas 2002, Rodriguez and Uribe 2002). According to Ghassan et al (2013) Pozzolana are effective at lowering the mortar's heat of hydration, which improves its workability and durability. Pozzolan can also improved concrete and mortar resistance to both sulfite attack and the alkali – silica reaction (ASR) which makes it beneficial to use in large concrete projects such as bridges and dams. Freedar and Tensing (2010) stated that even though mortar makes up as 7% of the total volume of a masonry wall, it plays a crucial role in the performance of the structure. It not only bounds the individual units together, but it also seals the building against moisture and air penetration the mortar is literally the glue that holds the wall system together, the primary ingredient in mortar is Portland cement and fine aggregate.

Shea-nut Shell

Shea-nut shell is the agricultural waste product obtained from Shea nut when the nut is removed. Shea-nut trees grow widely and naturally in West Africa; in Nigeria it is found mainly in the Northern part of the country. They only begin to bear fruit after about 20 years and do not reach maturity for 45years. Shea-nut shell may continue to produce nuts for up to 200years after reaching maturity Shea nut derived product have been used for years in Africa when the nut is properly removed from the fruit and dried it is a brown oral structure about the size, shape and colour of a pecan shell (1-3mni). With the nut is a seed and when the seed is removed

the shell becomes agricultural waste (Patrick, 2008). This study is aimed at investigating the effect of Shea-nut ash use as a partial replacement for Ordinary Portland cement in mortar which involves the determination of the chemical composition, evaluation of the setting time and compressive strength.

II. MATERIALS AND METHODS MATERIALS

The materials used for the study include Shea nut shell: This was collected in Doko Area, via Bida, Niger State, Nigeria.

Fine Aggregate. Fine aggregate was obtained from river Gbako Area in Bida, Niger State, Nigeria and it was free from deleterious substances.

Cement. Cement used was the Dangote brand of cement obtained from local distributor in Bida and it was of recent stock.

Water: Portable clean water obtained from bore hole in Federal Polytechnic Bida was used for mixing and curing the samples.

III. METHODS

The Shea-nut shell was dried and was subjected to uncontrolled combustion using open air burring. The ash was collected grinded and sieved with 200 micros sieve. The oxide composition of the Ash was conducted at the Heganda Scientific Laboratory Service Muniya, Ibadan. The Atomic Absorption spectrum meter (AAS) was used to determine its oxide composition. The oxide composition is shown in Table 1.

Table 1. Chemical Composition of Shea-nut Shell Ash (SSA)

Oxide	***Percentage Composition (%)***
$S_i 0_2$	*41.51*
$Al_2 0_3$	*22.62*
Cao	*5.18*
$Fe_2 0_3$	*9.05*
Mg 0	*1.04*
$Na_2 0_3$	*0.95*
$K_2 0$	*2.01*
$S0_3$	*0.81*
Others	*3.44*
LOI	*9.55*

The Shea-nut shell Ash (SSA) was used to replaced 5-20% by weight of the cement in mortar, at interval of 5%, mortar with no SSA serve as the control (0%) the mix ratio used was 1:6 (binder, fine aggregate) with water to binder ratio of 0.6 the vicat apparatus was used to determine the consistency and setting time of the Pozzolanic paste in accordance with British standard BS 12. The density test was carried out at the end of each curing period, the mortar cubes were weighed using weighing machine, and density was calculated as a mass of mortar cube (kg) divide by volume of mortar cube (m^3) and expressed as kg/m^3. The compressive strength measurement was made on 50mm cube mortar specimens in accordance with ASTM- C109 (7). 60 cubes were cast for replacement level of 0%, 5%, 10%, 15%, 20% and cured for 7days, 14days, 21days and 28days, at 3 cubes for each percentage replacement curing period.

IV. DISCUSSION OF RESULTS

Chemical composition

Table 1 show the oxide composition of the SSA. The results indicated that the Shea-nut Shell Ash has combined percentage of $Si0_2$ Al_2 0_3 and Fe $_20_3$ of 75.18%. This is in line with ASTMC 618-78 requirement of 70% minimum for Pozzolana. This indicates that it is a good pozzolanic material in accordance with the requirements in ASTM -C618. Since the sum of ($Si\ 0_2 + Al\ _20_3 + Fe_2\ 0_{3)}$ is greater than 70% SSA falls under the category of class F fly ash.

Setting Times of the OPC-SSA Paste.

The result of the average setting times of the various OPC – SSA combination is shown in table 2. Fig 1 shows the graph of the initial and final setting time against the various percentage replacements. The setting times increase with increase in the amount of SSA. The value of the initial setting time are 71minute, 213minutes, 236 minutes 257,minutes, 274minutes, 289minutes.

Table 2. Average Setting Times for SSA / OPC

Percentage Replacement (%)	*Initial Setting Time (mm)*	*Final Setting Time (mm)*
0	*71*	*183*
5	*213*	*312*
10	*236*	*351*
15	*257*	*389*
20	*274*	*411*

And the values of the final setting time (IST) are 183 minutes, 312minutes, 351minutes, 389minutes, 411minutes and 436minutes for 0%, 10%, 15%, 20% and 30% respectively. BS 12(1978) recommends initial setting time not to be less than 45minutes and final setting time (FST) not to be more than 10 hours respectively. SSA/OPC paste fall within this specification.

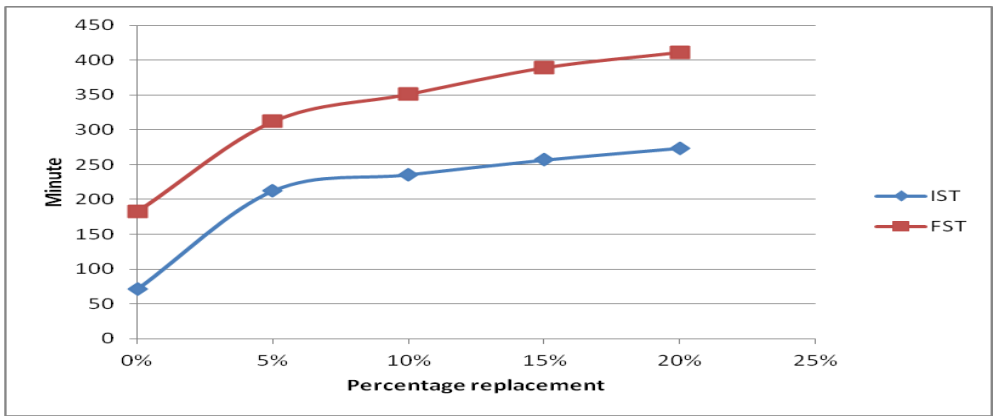

Fig: 1 Initial and final setting time

Compressive Strength

Results of the comprehensive strength are presented in Table 3

Table 3. Average Compressive Strength

Percentage Replacement (%)	*Curing Age (days)*	*Average Strength (N/mm2)*
0	*7*	*2.29*
	14	*2.68*
	21	*3.21*
	28	*4.50*
5	*7*	*2.16*
	14	*2.23*
	21	*2.82*
	28	*3.25*
10	*7*	*2.03*
	14	*2.14*
	21	*2. 76*
	28	*3.05*
15	*7*	*1.71*
	14	*2.06*
	21	*2,24*
	28	*2.61*
20	*7*	*1.69*
	14	*1.94*
	21	*2.01*
	28	*2.05*

The compressive strength results are presented in figure 2. The figure indicates that the compressive strength generally increases with increasing curing period and decrease with increasing SSA content. The highest strengths of 4.50N/mm^2 3.25N/mm^{2,} 3.05N/mm^2,2.61N/mm^2, and 2.05N/mm^2 at 28days curing period are obtained for 0%, 5% 10%, 15% and 20% SSA content respectively. The compressive strength of 3.25N/mm^2, 3.05Nmm^2, 2.61N/mm^2 for 0-15% replacement is above the minimum compressive strength of 2.5N/mm^2 stipulated by the Nigeria standard organization for sandcrete blocks. Shea-nut Shell Ash. Can be effectively use in masonry and production of secrete blocks. But the replacement level should not exceed 15%.

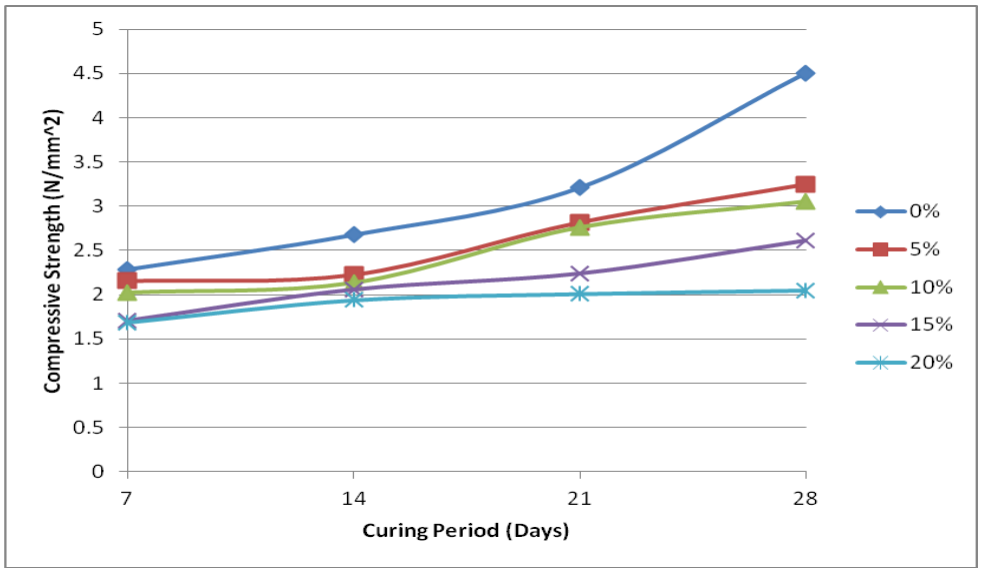

Fig: 2. Compressive Strength at Various Curing Age

V. CONCLUSION

Bases on the result obtained from the various test performed on the Shea-nut Shell Ash, the following conclusion can be deduced.

[1] The chemical analysis of the SSA ascertained it as a suitable material for use as a pozzolana, since ($si0_{2+}$ Al_20_3 + Fe_20_3) is more than 70%.

[2] The setting times increase with increasing OPC replacement

[3] The compressive strength generally increases with increase of curing period and decreases with increasing SSA content.

[4] The study reveals that 10 to 15% partial replacement of O P C with SSA using W/B ratio of 0.6 are suitable for mortar production.

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