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Groundnut shell ash as a partial replacement of cement in sandcrete blocks production

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Abstract

The production of sandcrete blocks using groundnut shell ash (GSA) as cement replacement was investigated. Six number sandcrete blocks were cast for each replacement levels (0, 10,20,30,40, and 50 percentage) with GSA. The blocks were cured and crushed at 7, 14, 21, and 28 days. The results show that the compressive strength ranges from 4.50 N/mm^2 to 0.26N/mm^2.The optimum replacement level was achieved at 20% with a corresponding strength of 3.58 N/mm^2. The strength at the optimum level was within the recommended limit of the Nigerian Industrial Standard (NIS) 87:2000. The results also showed that the strength decreases with increase of cement above 20% replacement. It was also observed that in the chemical composition of the GSA as compared to cement, the amount of K_2O was higher in GSA and also CaO was less than what is obtained in cement.

Keywords: Groundnut shell ash, Cement, Sandcrete blocks

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1. Introduction

Most building components in the tropics are made from cement, sand and water moulded into different geometrical shapes or sizes of which the most popular in Nigeria is the sandcrete blocks. Studies involving the quality of sancrete blocks have been conducted in many parts of the world. Some have shown the non uniformity in their quality (Abdullahi, 2005). Others have shown the effect of admixtures on the strength of the blocks (Oyekan, 2008; Oyekan, 2007; Nimityongskul and Daladar, 1995; Oluremi, 1990).

Groundnut is found in both the urban and rural areas of Nigeria. Groundnut shell is produced widely as a waste material after milling is done. The shell occupies 20–24% of the rough groundnut harvested, although the ratio differs by variety. About 58 tonnes of groundnut shell are generated annually in the world (Nakoo, 1999). Its application in some parts of human life will enhance sustainability of the environment and economic development especially in the developing countries.

The high cost of cement, used as binder, in the production of mortar, sandcrete blocks, lancrete bricks and concrete has led to a search for alternative. In addition to cost, high energy demand and emission of CO_2, which is responsible for global warming, the depletion of lime stone deposits is disadvantage associated with cement production. About 7% CO_2 is released into the atmosphere during cement production, which has a negative influence on ecology and future of human being arising from global warming (Oluremi , 1990).

Research on alternative to cement, has so far centred on the partial replacement of cement with different materials. In advanced countries, partial replacement of cement with pozzolans is well documented and recommended, (Hornbostel, 1991). Pozzolans as defined by (Oluremi, 1990) are siliceous material, which by itself possesses no cementitous properties but in processed form and finely divided form, react in the presence of water with lime, to form compounds of low solubility having cementitious properties. They are grouped into natural and artificial sources; clay and shale calcined to become active, volcanic tuff and pumicite are naturally occurring pozzolanas, whereas good blast furnace slag and fly ash are the artificial varieties. In advance countries, the use of fly ash, a residue obtained from the combustion of pulverized coal in partial replacement of cement is recommended within the range of 10-30% by weight of cement (Oluremi, 1990).

Mixtures of Portland cement and pozzolanic material is referred to as pozzolanic cements, such cement have the following advantages good resistance to chemical attack, low evolution of heat of hydration, economy, improvement of workability, reduction of bleeding and greater impermeability. Its disadvantages being, slower rate of strength development and increased shrinkage (Dashan and Kamang, 1999).

In the third world countries, the most common and readily available material that can be used to partially replace cement without economic implications are agro based wastes, notable ones are Acha husk ash (AHA), Bambara groundnut shell ash (BGSA), Bone powder ash (BPA), Groundnut shell ash (GSA), Rice husk ash (RHA) and Wood Ash (WA). Additional agro waste material include Ashes from the burning of dried banana leaves, bagass, bamboo leaves, some timber species, sawdust and periwinkle shell ash (PSA) (Michael, 1994).

Advantages to be derived from the use of agro waste in the partial replacement of cement are low capital cost per tonne production compared to cement, promotion of waste management at little cost, reduced pollution by these waste sand increased economy base of famers when such waste are sold, thereby encouraging more production, conservation of limestone deposits and a reduction in CO_2 emission (Mbiminah, 1992; Al-Khalaf and Yousif, 1984).

2. Materials and methods

Groundnut shell was obtained from sources within Yola and Hong in Adamawa state. The laboratory analyses were carried out at Ashaka cement PLC quality control laboratory and Civil Engineering Department laboratory of Modibbo Adama University of Technology, Yola. The shell was burnt in electric kiln at a temperature of 550^{o}C. The analysis of the groundnut shell ash was carried out by x-ray fluorescence analysis using fused bead XRF VFD45000. Silt content and particle size analysis was carried out on the sand sample to ensure its suitability for block making in accordance to BS8110 (1985). The mix ratio adopted is one part of binder to eight parts of sand (1:8) at 0%,10%,20%,30%,40%, and 50% replacement levels of cement with the groundnut shell ash. The quantities of the materials were batched by weight. The mixing and tamping was done manually and about 150 block were cast altogether. The BUA brand of ordinary Portland cement was used in this investigation. The sprinkling method of curing was adopted in accordance with NIS (2000) and the compressive strengths of the blocks were tested in accordance to ASTM (1992).

3. Results and discussions

3.1. Specific gravity

The specific gravity of the groundnut shell ash and the sand used were 2.10 and 2.68 respectively, as shown in table 1. Oyetola and Abdullahi (2006) reported that the value of specific gravity ranges from 1.9 to 2.4 for pulverized ash and 2.6 to 2.7 for natural aggregates. Both the sand and the ash used complied with these ranges. The specific gravity of any material is a function of its weight. Since the weight of ash is far less than the weight of cement with specific gravity of 3.15, as such an inevitable reduction in the weight of composite sandcrete block was observed.

Table 1. Result of the specific gravity and silt content of groundnut shell ash and sand

Materia	**Specific Gravity**	**Silt Content (%)**
Groundnut shell ash	2.10	0.00
Sand	2.68	3.75

3.2. Silt content

According to Oyetola and Abdullahi (2006), a silt content of 3% to 8% for sand is permissible. Table 1 shows that the silt content of the sand used was 3.7%. This confirms further that the sand was adequate for block making.

3.3. The slump

Table 2 indicates that mixes with greater groundnut shell ash content required a greater quantity of water to achieve a reasonable workability. The groundnut shell ash has greater water adsorption ability than the cement which could be due to its high carbon content.

Table 2. Variation of water/binder ratio with percentage replacement of ordinary Portland cement with groundnut shell ash

Percentage of Groundnut Shell Ash	0	10	20	30	40	50
Water/Binder Ratio	0.52	0.55	0.56	0.57	0.58	0.59
Slump(mm)	15	30	25	20	25	20

3.4. Setting time

Table 3 shows the percentage replacement of ordinary Portland cement with groundnut shell ash with their setting time. The result indicates a delay in both the initial and final setting times of the block as the quantity of the groundnut shell ash was increased in the mix. The exothermic reaction involved in the hydration of cement generates heat which contributes to the faster setting of the blocks. The addition of the ash to the mix may have reduced the amount of heat generated; as a result, the paste gets to harden more slowly. The impact is obvious where no addition of the groundnut shell ash (0% replacement) where the initial and final setting time was 95 and 155 minutes respectively, while at 50%, the initial and final setting time was as high as 436 and 821 minutes respectively, indicating about 341minutes in the former and 666 ,minutes in the latter delays in setting. The rate at which the delays occurred was irregular. The time interval between the initial and final setting times for the replacement levels were 60, 145, 323, 380, 380 and 385minutes for 0%, 10%, 20% , 30% , 40% and 50% replacement levels respectively. The setting time delay was increasing as the groundnut shell was added with the maximum as 385minutes at the 50% replacement level.

Table 3. Variation of setting time with increase in groundnut shell ash replacement

Groundnut Shell Ash Replacement of Cement (%)	0	10	20	30	40	50
Initial Setting Time (minutes)	95	185	197	312	380	436
Final Setting Time (minutes)	155	330	520	692	760	821

3.5. Compressive strength

Table 4 shows that the result of compressive strengths of the sandcrete blocks. The result shows gradual increase in strength with age of curing up to 28 days at various replacement levels. And there is an observed decrease in strength with increasing groundnut shell ash content. From the result blocks made at 20%, 10%, and 0% replacement levels at the 28th day of curing were having 3.58N/mm^2, 4.03N/mm^2, and 4.50N/mm^2 strengths respectively which were within the required 3.5N/mm^2 for sandcrete blocks. The maximum replacement level to achieve the maximum compressive strength is 20% as indicated in the table.

Table 4. Result of the compressive strength test of the composite blocks

% REPLACEMENT	AGE OF CURING (days)	AVERAGE CRUSHING LOAD (KN)	COMPREHENSIVE STRENGTH (N/mm^2)
0% GSA	7	56	1.60
	14	89	2.53
	21	126	3.60
	28	158	4.50
10% GSA	7	45	1.30
	14	80	2.30
	21	113	3.20
	28	142	4.03
20%GSA	7	39	1.11
	14	75	2.10
	21	99	2.80
	28	126	3.58
30% GSA	7	28	0.80
	14	43	1.22
	21	63	1.80
	28	91	2.59
40% GSA	7	12	0.34
	14	24	0.68
	21	36	1.02
	28	41	1.16
50% GSA	7	9	0.26
	14	14	0.40
	21	19	0.34
	28	22	0.63

Legend: GSA - Groundnut Shell Ash

3.6. Chemical analysis of GSA

Table 5 shows the chemical composition of Groundnut shall ashes. Generally, the percentages of the various parameters in the groundnut shell ashes were within the ranges obtained for cement. However the percentage composition for Calcium Oxide (CaO) in GSA was below the minimum obtained in Cement and also the percentage of potassium Oxide (K_2O) had exceeded the maximum value obtained in Cement.

Table 4. Result of x-ray fluorescence analysis of GSA in comparison to Cement

PARAMETERS	GSA SAMPLE (%)	*CEMENT (% Ranges)
SiO_2	26.96	17 – 25
Al_2O_3	5.82	3 – 8
Fe_2O_3	0.50	0.5 – 0.6
CaO	9.5	60 – 67
MgO	5.60	1 – 6
SO_3	1.86	1 – 2
K_2O	20.02	0.1 – 3
Na_2O	1.15	0.1 – 3
P_2O_5	2.0	0.1 – 0.5
MnO_2	0.32	0.1 – 3
TiO_2	0.69	0.1 – 1
LOI	22.00	17 – 25
TOTAL	97.47	

** Source: Ashaka Cement factory, Nigeria*

4. Conclusion and recommendations

The following conclusions and recommendations were drawn from the results;

1. The groundnut shell ash may be used as a partial replacement of cement in sandcrete block to achieve a satisfactory compressive strength at about 20 percentage of the binder quantity.
2. The water requirement for a given workability increases as the groundnut shell ash quantity increases in the morter.
3. The setting times of a composite binder sandcrete block increases as the ash content increases in the mix.
4. The compressive strength of sandcrete block for a particular mix ratio decreases as its groundnut shell ash content increases.
5. Other measures should be explored towards the improvement of the GSA quality to achieve adequate strength at maximum replacement levels.
6. There is a great need to sensitize the public especially commercial sandcrete block manufacturers on the dangers accompanying the manufacture of substandard blocks and how they would use groundnut shell ash as a partial replacement of cement to achieve the profit they desire without lowering the standard.

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