WASTE TO WEALTH: A STUDY OF LATERITE BRICKS PRODUCED USING BLENDED INCINERATED CORN-COB ASH CEMENT

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In recent past good attempts have been made for the successful utilization of various agricultural and industrial waste to save environmental pollution. Currently Nigeria has taken a major initiative on developing its infrastructures such as express highways, power projects, industrial structures and mass housing schemes etc., to meet the requirements of globalization, in the construction of buildings and other structures. River sand and Ordinary Portland cement (OPC) which is one of the major constituents used in the production of conventional block has become very expensive, while river sand is becoming scarce due to depletion of river bed. As a result, the suitability of stabilizing laterite brick with Corn cob ash (CCA) an agricultural waste was sought. The Physical, mechanical and durability properties of bricks produced using laterite stabilized with corn cob ash incorporating OPC cement as admixture were investigated. This paper reports the experimental study which investigated the influence of CCA stabilization of 0%, 2%, 4%, 6%, 8% and 10% at 1%, 2%, 3% cement admixture. The experimental results showed that the compressive strength property increases with age at curing. Stabilization up to 6% was found to enhance the strength.

Keywords: blended cement, compressive strength, incinerated corn-cob, laterite bricks

INTRODUCTION

Corn cob is a waste product from subsistence food consumption and agricultural processing industries. These materials constitute environmental challenge and the need has arisen to reuse these materials for economically viable ventures. The disposal of the corn cob presents a serious ecological problem to the processing industries (Oladeji, 2010). Therefore the development of suitable scientific and economic method of recycling of corn cob is very urgent and imperative. Research has shown that corn cob materials have high silica contents. The ashes from these agricultural wastes are also of high binding properties (Mohamed and Taher, 2006). In addition, since the pulverized form of these materials have very fine grain sizes; they can therefore act as good blend to the laterite soil. Also it is expected that some of these materials will burn off at a very high temperature given rise to better permeability of the moulding laterite soil. The upshot of this research will help in the production of low-cost environmentally friendly laterite bricks. The exploitation of these agricultural waste products will also help the environmentalist in solving the pollution quandary allied with the disposal of these materials.

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LITERATURE REVIEW

Corn cob, a farming waste product obtained from maize or corn, is the most important cereal crop in sub-Saharan Africa. There are millions of tons of agricultural dregs produced annually in Nigeria. For example, the quantity of maize cob, groundnut shell, rice husk and sugar cane fibres generated annually in Africa is estimated to total over 12 million metric tons (National Bureau of statistics, 2006). conceivably, up to half of these wastes are prospective low-cost sources of alternative Building materials but hardly, if any, known attempt has been made at a commercial level to harness these vast but grossly derelict resources to realize socio-economic benefits for the peoples of the region.

According to Food and Agriculture Organisation (FAO) data, 589 million tons of maize were produced worldwide in the year 2000 (FAO, 2002). The United States was the largest maize producer having 43% of world production. Africa produced 7% of the world's maize (IITA 2002). Nigeria was the second largest producer of maize in Africa in the year 2001 with 4.62 million tons. South Africa the Africa continent's largest maize producer harvested its biggest crop in three decades at 12.815 million tons in the 2009/10 season. South Africa's annual maize consumption is between 8 and 9 million tons and the surplus is destined for export (Reuters Africa, 2011).

There had been various research efforts on the use of corn cob ash (CCA) as a pozzolan in blended cement concrete. Ogunfolami (1995) considered mixing of the CCA with Ordinary Portland Cement at the point of need i.e. on site. Adesanya and Raheem (2009a) studied the use of CCA blended cement produced in the controlled environment of a factory as reported by Adesanya and Raheem (2009b), to produce concrete specimens. Both studies concluded that the compressive strength of the CCA-blended cement concrete is lower than that of plain concrete (the control) at early curing ages but improves significantly at later ages (after 90 days). Thus, it is expedient to look for ways of increasing the strength at early ages. This study is unique on its own because it investigated the suitability of incorporating CCA blended cement to stabilize laterite bricks and not on concrete as previous research works as recorded.

Inspite of the long proven use of earth wall construction in Nigeria, earth bricks are still mostly used for dwellings, which are built without formal authorization such as obtained in the rural housing or uncontrolled low income housing in the urban areas (Easton, 1987). Various materials have been used to stabilize laterite for the sole purpose of making bricks. The prominent materials are cement, lime, bitumen, burnt brick, corn-cob ash and clay (Olateju, 1991a; Adesanya, 2001). The progress made with each of these materials are well documented in journals and conference papers (Okoli and Zubairu, 2002). But in-spite of the elaborate work that has being done on laterite bricks, little has been done or documented on corn cob stabilized laterite bricks, which record shows has cementitious particle which makes it serve as a good binder (Raheem and Adesanya, 2011).

Various organizations and individuals have achieved several minimum compressive strength requirements for soil cement a brick. The specified minimum strength for blocks tested at 28 days is $2.5N/mm^2$ (NIS, 1976). It was suggested that generally, most soils, which are well compacted will be strong enough for single storey houses and a minimum strength of $2.76N/mm^2$ would appear to be adequate. Most other recommendations for soil blocks vary from $2.10N/mm^2$ to $3.50N/mm^2$.

In Minna, the capital of Niger State of Nigeria and its surrounding towns, the most common walling materials are the conventional sandcrete blocks and locally produced mud bricks. The cost of sandcrete blocks coupled with the low strength properties of commercially available blocks necessitated the search for an alternative like locally produced mud bricks. These are smaller than sandcrete blocks and therefore require more bonding mortar. The production of locally produced mud bricks is rigorous and the life cycle of the bricks are short compared to the sandcrete blocks or the expensive and scare factory produced clay bricks. In Minna and other locations within Niger State, and areas within the North central zones, abundant lateritic soil and corn cob dump exists which can be harnessed for brick production. This potential is not being maximized. Compared to sandcrete blocks, it is economic to use laterite and corn cob ash cement for brick production because very little cement is required as admixture and the cost of transportation is eliminated as production takes place on site. Compared to fired clay bricks, the production of corn cob ash cement laterite bricks does not involve the firing process.

MATERIALS AND METHOD

The material used for this research includes Laterite, Cement, Corncob ash and water. The Laterite soil sample was sourced from a borrow pit in Federal University of Technology, Minna permanent site, Gidan kwano Village in Niger State, Nigeria. It was checked to ensure that it contains no substances that could impair its binder ability or make it unfit. The grading of the laterite was carried out using the British Standard sieves. The following sieve sizes 9.5mm, 5.00mm, 3.35mm, 2.00mm, 1.18mm, 850µm, 600µm, 420µm, 150µm and 75µm were used (BS 812: Part 103). Particles retained on 9.5mm sieve were considered too large and were not used in the study (Plate 1). Corn cob (CC) used in this investigation was collected from Sarki Pawa Area of Niger State in Nigeria as a waste from the waste dump. It was then sun dried (Plate 2) and burnt into ash, the ash was subsequently calcined to 1000^0c, and the resulting powder was grinded and sieved with 75µm Sieve in Building Department Laboratory of the Federal University of Technology, Minna. The CCA blended cement used was produced by efficient mixing (Plate 3). The cement used was locally manufactured ASTM Type I Portland cement called 'Dangote' which was purchased from the open market and it conformed to BS EN 197[21]. Potable water from the municipal water supply was used for this study. Adequate precautions were taken to make void the materials to be used from deleterious materials.

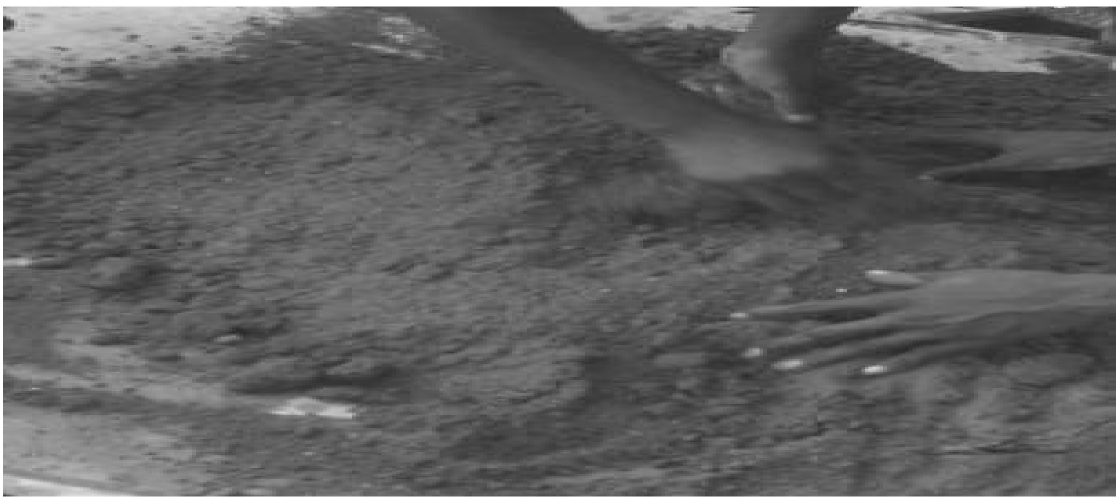

Plate 1: Preparation of Laterite

Plate 2: Corn cob sun drying Plate 3: Corn cob ash

Moulding of the Block

Manual block moulding machine was used, which has the capacity to mould two blocks simultaneously. The dimension of the moulds is 240mmX110mmX100mm (see Plate 4). The moulds were normally filled to the brim and again compacted before leveling off. A total of 270 bricks were produced (see Plate 5). In the mixing of the laterite and the binders, Water was added until the mix became mouldable but it was observed that the higher the proportion of CCA and OPC admixture, the greater the volume of water needed to make the mix mouldable. The stabilization was done with CCA and OPC as admixture at 0%, 2%, 4%, 6%, 8% and 10% at 0%, 1%, 2% and 3% cement admixture.

Plate 4: Bricks Manual Moulding Machine Plate 5: Staked Bricks

Curing and Testing of Blocks

All the samples were cured under waterproofing material for the first seven days; thereafter the bricks were sun dried for two weeks (14 days), so as to allow complete hydration process of the binders, as also explained by Ola (1976). The Laterite bricks produced were subsequently tested to failure using the compressive strength crushing machine.

Washability Test

Water was poured on the samples from a height of about 3.0m for 5 minutes by means of a controlled shower tap. The samples were then rubbed with fingers; the quantity and the ease with which soil particles came off were used to judge the erosion resistance of the bricks. (see Plate 6)

Plate 6: Washability Test samples

Water Absorption

Three (3) bricks, each for each mix ratio were tested. The bricks were allowed to dry in an oven at 110°C to 115°C till they attain a constant weight, which usually take place in 48 hours. They were then allowed to cool at room temperature, which took four (4) hours and weight W_1 was measured, they were then kept in clear water at 27 ± 2°C for 24 hours and then wiped dry with a damp cloth and weight W_2 was measured. The average percentage of water absorbed as percentage of dry weight is shown in Table 3. The values were not greater than the values specified by Varghese (2006).

$$\% \text{ Absorption} = \{(W_2 - W_1)/W_1\} \times 100$$

Table 1: Chemical composition of corn cob ash (CCA)

Chemical Constituents	Composition (%)			
	Sample 1	Sample 2	Sample 2	Average
SiO_2	67.33	65.39	66.41	66.38
Al_2O_3	7.34	9.14	5.97	7.48
Fe_2O_3	3.74	5.61	3.97	4.44
CaO	10.29	12.89	11.53	11.57
MgO	1.82	2.33	2.02	2.06
SO_3	1.11	1.10	1.01	1.07
Na_2O	0.39	0.48	0.36	0.41
K_2O	4.20	4.92	5.64	4.92
$S1O_2 + Al_2O_3$	74.67	74.53	72.38	73.86

Source: Raheem, A.A. and Adesanya D.A. (2011).

Table 2: Summary of Physical Properties of Termite Mound Soil.

PARAMETER	VALUES
Moisture Content (%)	20.90
Coefficient Of Uniformity (CU)	8.50
Coefficient Of Curvature (CC)	1.18
Specific Gravity	2.49
Fineness Modulus (F.M.)	2.91
Liquid Limit (LL) %	37.39
Plastic Limit (PL) %	17.33
Plastic Index (%)	20.05
Linear shrinkage (%)	14.29
Bulk density (Kg/m^3)	1753
AASHTO classification	A-7-6
Colour	Reddish-Brown

Three field tests were carried out on the Laterite soil, these are namely; the smell, washing, and touch tests to determine the presence of organic matters. The sedimentation test to determine the gravel sand and clay proportions and the Cigar test to verify the consistency of the soil. The moisture was determined in accordance with British Standard on Methods of Soil for Civil Engineering Purposes for conducting the Atterberg limit tests by the casagrande method to ascertain the Liquid Limit (LL) and the Plastic Limit (PL) and also in the test for the determination of the specific gravity was followed (BS 1377).

RESULTS AND DISCUSSIONS

The chemical composition of CCA as given by Adesanya and Raheem (2011), which makes it possible to be used as a pozzolan, is presented in Table 1. The results shows that the combined $SiO_2 + Al_2O_3 + Fe_2O_3$ (Silicon dioxide, Aluminium oxide, Ion oxide content) is 78.30% which meets the ASTM C618 – 78 minimum limit 0f 70%. The chemical properties of CCA are therefore adequate in Pozzolana. Table 2 shows that CU and CC are 8.50 and 1.18 respectively, which describe the soil to be well graded thus, meeting the design requirements since it possesses a balanced particle distribution. The result of Atterberg limit test performed on the Laterite soil, the average plasticity index is 17.33% and specific gravity is 2.49 which meets the stipulated value and indicates that the soil is good and cohesive (BS 1377).

The cigar test gives an average broken length of 7.35cm, which falls within the range of 4cm and 8cm limit therefore showing that the laterite soil is good for producing bricks, but not organic, as it did not give out a misty smell (UNCSH, 1987). The result of the field test on the soil showed that it is not sticky to touch and therefore has low clay content. Presented in Table 3, is the test result of water absorption test performed on the bricks which shows that the bricks meet up with ASTM C 67 specification of 8% for Engineering blocks, which infers that the bricks produced can stand moist condition in service and will not crumble in water but will be susceptible to weathering.

The results of the compressive strength development with hydration period of 7, 14, 21 days for all percentage stabilization at varying percentage cement admixture are presented in Table 4. The maximum compressive strength recorded at 21 days were 1.45 N/mm^2, 3.65N/mm^2, 4.76N/mm^2, and 5.21N/mm^2 for the 0%, 1%, 2%,and 3% cement admixture respectively, attained at 6% CCA stabilization, the values increases with stabilization and then decreased slowly as the percentage stabilization increased. At 1% cement admixture, the maximum compressive strength is higher than 2.5N/mm^2 and 2.8N/mm^2 bare minimum requirement by the Standard Organization of Nigeria (SON) and the British Standard Institution for Mansory Units, Cratera (1985). Table 5 shows the test result on abrasion performed on the bricks. It can be said that the bricks are less susceptible to abrasion due to wind and water as compared to lateritic soil in Olaoye and Izam, 2004 study. The more the weight of the bricks the less prone they are to abrasion. However, if the surface is well treated with improved surface finish of cement plaster, it will resist abrasion better.

Table 3: Density, Erosion Resistance and Water Absorption of Bricks containing 3% cement admixture.

CCA content (%)	Density (Kg/m^3)	Erosion Resistance (Grade*)	Water Absorption (%)
0%	1734	1	11.45
2%	1782	2	10.87
4%	1814	2	10.70
6%	1826	3	9.40
8%	1867	4	6.50
10%	1892	4	8.20

* Grade 1 – Very weak washability resistance,

Grade 2 – Weak washability resistance,

Grade 3 – Medium washability resistance,

Grade 4 – High washability resistance,

Grade 5 – Very high washability resistance.

Table 4: Compressive strengths (CS) test on CCA stabilized Bricks at Varying OPC admixture.

CCA content (%)	CS @0%OPC (N/mm^2)			CS @1% OPC (N/mm^2)			CS @2% OPC (N/mm^2)			CS @3% OPC (N/mm^2)		
	7	14	21	7	14	21	7	14	21	7	14	21
0	0.33	0.42	0.58	0.71	0.92	1.87	1.83	2.12	2.78	2.28	2.87	3.02
2	0.38	0.57	0.78	1.02	1.93	2.56	2.22	2.65	3.43	2.99	3.22	3.64
4	0.44	0.62	0.93	1.14	1.54	3.03	2.18	2.98	3.96	3.25	3.43	4.80
6	0.92	1.07	1.45	1.98	2.67	3.65	2.43	3.16	4.76	3.02	3.87	5.21
8	0.86	0.92	1.28	1.81	2.18	3.31	2.27	3.91	4.13	2.85	3.31	4.47
10	0.69	0.85	1.18	1.63	2.19	3.18	2.10	2.67	3.18	2.71	3.18	4.03

Table 5: Abrasion test on the CCA stabilized Laterite Brick containing 3% cement admixture.

CCA content (%)	Weight Before Brushing W_1(g)	Weight After Brushing W_2(g)	Loss In Weight (g)	% Loss In Weight	Depth Of Penetration (mm)
0%	5126	5118	8	0.10	0.82
2%	5253	5248	5	0.06	0.49
4%	5321	5316	5	0.06	0.14
6%	5384	5381	3	0.04	0.11
8%	5631	5628	3	0.04	0.07
10%	5753	5750	3	0.04	0.04

CONCLUSION

The chemical analysis of the corn cob ash (CCA) shows that the combined SiO_2 + Al_2O_3 + Fe_2O_3 was found to be 78.30% of the total composition of ash, it thus meet the requirement for alternative stabilizer (Pozzolana) and reduces cost. The result obtained from 21 days dry compressive strength of bricks were 3.65N/mm^2, 4.76N/mm^2, and 5.21N/mm^2 for 1%, 2%,and 3% cement admixture respectively at 6% stabilization with corn cob ash (CCA). The bricks are therefore recommended for use in load bearing walls for bungalows and animal pens. CCA stabilized bricks can withstand moderate weather conditions in service especially with faces plastered to avoid early deterioration.

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