STRENGTH PROPERTIES OF CONCRETE MADE WITH CASSAVA PEEL ASH (CPA) AS A PARTIAL REPLACEMENT OF CEMENT

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ABSTRACT:
This paper discusses the effect of cassava peel ash (CPA) on workability level and its maintenance of fresh paste and concrete setting time, strength development and optimization. The research programme examined the cassava peel concrete to varying levels of cement stabilization with the views of establishing the percentage of the ash that can be used in the cement matrix. The result obtained shows that CPA can be blended up to 10% of cement replacement for concrete making.

Keywords: *Cassava peel ash (CPA), compressive strength, workability, setting time.*

INTRODUCTION

United Nations (UN) convention has for long recognized the acute shortage of housing to properly cater for under sheltered large populace of the world and proactively set 2015 as a millennium goal for housing for all, yet the housing situations in the developing countries are still characterized by lots of problems. The conventional building materials are imported and their prices, coupled with the technological knowhow are considerably beyond the capacity of the average rural dwellers. In order to stem the over dependence on conventional building materials, research works have been focused on the possibility of knowing the properties of the abundantly available alternatives to improve on them for low – cost housing. The global production of cement contributes about 3.4% of the total CO_2 into the earth's atmosphere (CDIAC, 2003). This has motivated efforts by researchers to develop alternative materials that reduce the amount of CO_2 and other toxic gases that are released into the environment. Hence, the need for sustainable, energy efficient construction materials has oriented extensive research on alternative materials that can reduce the cost and environmental impact of construction processes. It was reported by Kamang and Asabo (2001) that, to tackle the immense task of providing adequate shelter and its services for the existing population as well as the anticipated increase, it is absolutely essential that alternatives which can make use of local available raw materials and abundant local labour rather than the scarce cartel should be developed and used. Concrete and steel are the two most commonly used structural materials for construction purposes and they sometimes complement one another (Neville, 1981). Concrete being the most widely used construction material today, requires a lot of efforts to reduce its cost of production. This is achieved by reducing the cost of the most essential and expensive constituent of concrete which is cement been. One of way of reducing cement cost in concrete is by partially replacing it with cheaper, but cementitious, materials known as Pozzolana. Accordingly over the years, research works have been focused on th possibility of knowing the r operties of abundantly available cal materials; particularly agricultural waste ash and improve on it, to meet both service and engineering requirements (Ademiluyi,1985). Ashes derived from the incineration of volcanic rocks, agricultural waste or residues notably rice – husk, baggash, etc, have been found by various researchers to be pozzolanic materials containing reactive silica or alumina which, when mixed in water posses cementatious properties, Sima (1974). Cassava peel ash (CPA) is a by – product of the combustion of refuse generated during cassava processing. Cassava is a root tuber crop grown all over Nigeria and other developing countries with favourable weather conditions. It is rich in carbohydrate, starch, protein, fats, ash, and fibre. This make it a very good and highly reliable source of food energy, sweetener and industrial raw materials, FMINO (2005).

The partial replacement of Ordinary Portland cement (OPC) with CPA in concrete production should be encouraged especially in the middle – belt and southern part of Nigeria. Considering its major benefits, in the area of building cost reduction in rural areas. The availability of the cassava peel in large quantity as waste/refuse in the producing regions of the country is an added advantage to increased level of construction activities.

The main objective of this research therefore is to ascertain the properties of concrete made with cassava peel ash (CPA) as a partial replacement of Ordinary Portland cement (OPC) and hence establish the optimum percentages of CPA content that will give the optimum strength. The chemical analysis of the ash was undertaken to determine the suitability of CPA, through its chemical composition, as a Pozzolana.

MATERIALS AND METHOD

The Cassava peel used for this research was collected, sorted and evenly spread out on polythene sheeting and turned over at intervals for proper drying. The conversion of the cassava peel to ash was achieved by combustion in two stages. Initial open air combustion was carried out in an aluminum container as a means of reduction of both volume and weight of cassava peel. The temperature of combustion rose to 177^{oC}. The second stage of combustion was undertaken under the laboratory conditions to reduce the ash to a fine physical and chemical uniform matrix. Combustion of ash was carried out in a Gallenkamp electrical furnace, with maximum temperature of 1200^{oC}. The crucibles of the furnace were filled with ash and temperature progressively rose to 1000^{oC} over a period of 20 minutes. The incinerated refuse ash was sieved on a BS. Sieve No 200(75 μm) size. Physical and chemical properties of the CPA were carried out and the result compares with other Pozzolana and OPC are shown in Table 1. Ordinary Portland cement used throughout the test conforms to BS.1881 (1983). The fine aggregate used was river sharp sand, zone 2 types, and the coarse aggregate used was crushed and graded gravel with a maximum size of 20mm diameter conforms to the specification of BS. 882 (1975).

Fresh Paste and Concrete Setting

The initial and final setting time tests were performed on both plain cement pastes, which is at 0% replacement and those having cassava peels ash at (CPA) content of 5, 10, 15, 20, and 25% replacement of cement by volume respectively (Figure 1).

Workability

Workability of each mix was assessed using the slump and compacting factor tests in accordance with the provision of BS 882 (1975). The result is shown in Table 2.

Compressive Strength of Concrete

A total of 72 cubes, using a concrete mould of 150mm x 150mm x 150mm were cast. They were subsequently cured in curing tank for 3, 7, 14, and 28 days at a room temperature of 26

2°C by immersion. Average of three (3) cubes were crushed for each test using an electronic 2000 motorized twin gauge compressive machine, in accordance with BS.1881 (1983). The result is presented in Table 3.

RESULTS AND DISCUSSION

The result of the physical properties of cassava peel ash for this study shows that the specific gravity, moisture content, and loose bulk density are 1.72, 2.09%, and 4.89Kg/m3 respectively. The study also shows that the PH value of the ash is 10.0. This shows that the ash is alkaline in nature. The moisture content of the ash is hydroscopic in nature.

Table 1 Shows the chemical composition of cassava peel ash (CPA) as compared with other pozzolana commonly in used, the combined SiO_2 + Al_2O_3 + Fe_2O_3 (Silicon dioxide, Aluminium oxide, Ion oxide content) was 70% which meets the ASTM c1618 - 78 minimum limit 0f 70%. The *chemical properties of CPA are* therefore adequate in Pozzolana. The combined essential oxides of CPA at 70% is lesser than that of Rice Husk Ash (RHA) and Pulverized Fuel Ash (PFA) at 73% and 85% respectively (Kamang and Asabo, 2001). The Calcium oxide (Cao) content of the CPA was 5.17% which is higher than that of RHA at 0.16%, Ikpon (1993) and just a tenth of that of Ordinary Portland Cement (OPC) at 63%, Calcium oxide being one of the principal components of OPC, account for its rate of hydration (Neville, 1981). The moisture and carbon contents of CPA expressed as loss – on – ignition (L.O.I) was 0.1%, L.O.I should not exceed 7%, according to ASTM c1618 (1978).

The effect of OPC replacement with CPA on the initial and final setting time is presented in figure 1. The result shown may be due to the slower pace of heat induced evaporation of water from OPC-CPA paste due to the lower cement content. The reaction between cement and water is exothermic, and greater amount of heat would be evolved by the plain cement paste because of its higher cement content. This result also shows that the setting time increased with the CPA content of the paste. It is obvious that the higher the CPA content, the lower would be the cement content of the paste and therefore the slower would be the pace of heat induced evaporation.

The setting times were however still within the recommended range for ordinary Portland cement paste of 45minutes to 12 hours (Menta and Pirtz, (1978).

Table 2 shows that the workability of the material is affected to a greater degree by the addition of the ash because the higher the percentage replacement of the ash, the lower its workability.

Table 3 shows the development of the compressive strength of cassava peel ash concrete at various percentage of replacement. The results show that the compressive strength decreases as the percentage of ash increases, the strengths of about 87%, 81%, and 71% at 5%, 10%, and 15% ash were recorded in 28days. However, optimum result is obtained between 5% and 10% replacement with strengths of 20.77 N/mm^2 and 19.32 N/mm^2 respectively for C_{25} target strength, in 28days of curing.

Table 1: Comparison of CPA chemical content, percent with other Pozzolanas and OPC

Oxide	Content, percent					
	CPA	**RHA**	**BA**	**VA**	**IMWA**	**OPC**
Fe_2O_3	3.39	0.95	3.95	2.13	2.10	0.5-0.6
SiO_2	62.30	67.3	57.95	48.75	48.44	17-25
Al_2O_3	3.76	4.9	8.23	16.25	4.87	3-8
CaO	5.17	1.36	4.52	11.67	22.35	60-67
MgO	5.04	1.81	1.71	4.24	8.16	0.1-4.0
Na_2O						0.5-1.3
K_2O						-
P_2O_5						0.1-1.2
TiO_2						0.1-0.4
SO_3						1-3
L.O.I*	0.1	17.78	5.00	2.71	6.94	-
% of Essential Oxides (Fe_2O_3+Si0+ Al203)*	69.45	73.15	70.14	67.13	55.41	20.5-33.6

Sources: Neville (1992), Kamang and Asabo (2001), Ikpong (1993), BS: 3892 (1993), Muazu (2007), Alhassan and Mustapha (2007).

* The ASTM c618-84 requires a combined minimum content of 70% of $SiO_2 + Al_2O_3 + Fe_2O_3$ for pozzolana and L.O.I not exceeding 12%, 7% for BS 3892: part 1; 1982.

Legend:

CPA	=	Cassava Peel Ash
RHA	=	Rice Husk Ash
BA	=	BagashAsh
VA	=	Volcanic Ash
IMWA	=	Incinerated Municipal Waste Ash
OPC	=	Ordinary Porland Cement

Table 2: Workability of Concrete with Ash

Ash (%)	Slump (mm)	Compacting Factor
0	100	0.963
5	85	0.947
10	83	0.932
15	78	0.911
20	74	0.905
25	60	0.879

Source: Field survey, 2010.

Table 3: Strength Development of Concrete with Ash at varying hydration period in N/mm^2

Ash (%)	3 days	7 days	14 days	28 days
0	15.71	19.14	23.59	29.96
5	14.30	16.23	19.81	25.97
10	12.64	13.80	18.53	24.15
15	11.26	13.36	17.78	21.31
20	10.26	10.70	15.94	19.95
25	7.33	8.50	12.16	16.07

Source: Field survey, 2010

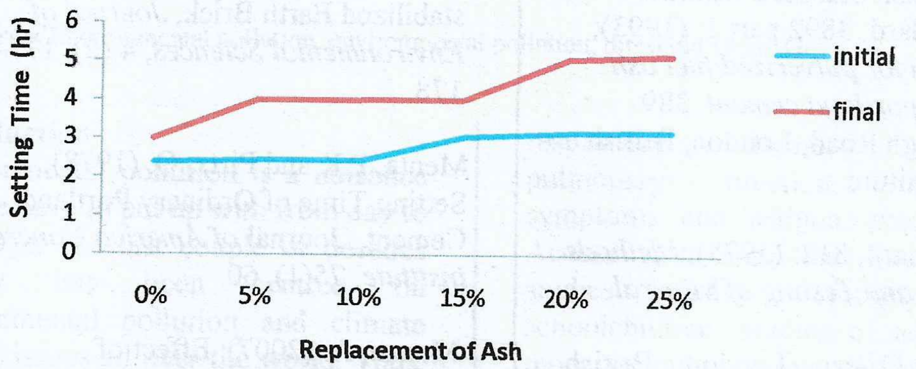

Fig 1: Setting Time of Cement Paste with Cassava peel Ash (CPA)

Source: Field survey, 2010.

CONCLUSION

From the results of the tests and analysis carried out in this study, the following conclusions can be drawn: The cassava peel ash can be blended in small amount up to 10% replacement by weight or volume of cement in concrete making. For increased percentage, it can be used for light weight concrete and further be used to reduce the quantity of cement in stabilized block work especially in low – cost housing in rural areas.

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AN EVALUATION OF COMPRESSIVE STRENGTH OF CONCRETE MADE WITH RICE HUSK ASH OBTAINED BY OPEN AIR BURNING

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ABSTRACT

Pozzolanic materials have long demonstrated their effectiveness in producing high performance concrete. Artificial pozzolanas such as rice husk ash have gained acceptance as supplementary cementing materials in many parts of the world. This work evaluates the Compressive strength of rice husk ash (RHA) as a partial replacement for ordinary Portland cement (OPC) in concrete. A total of 90 cubes of 150mm dimensions were cast with cement replacement level by RHA ranging from 0 to 40%, while a control mix of 28-day target strength of 25N/mm^2 was adopted. The cubes were cured in water and tested for compressive strength at 7, 14, 21 and 28 days. Stripping of the concrete cubes from the mould was carefully done after 24 hours of the concrete setting under air. The results with graph plotted show the trend of strength development of the samples. The results show that the density and compressive strength of concrete decreased with increase in rice husk ash content. The 28-day, density and compressive strength dropped from 2485kg/m^3 to 2122kg/m^3 (i.e.14.61% loss) and from 27.21N/mm^2 to 19.00 (i.e.30.17% loss) respectively for 0-40% variation of RHA content. The 10% RHA sample was found to show a promise of attaining similar strength as the control mix at a later curing age having progressed to about 90% (i.e. 24.07N/mm^2—89%) of the design Strength by the 28-day.

Key words: Admixture, Cement, Concrete strength, Compressive, Pozzolanic properties, Rice husk ash,

INTRODUCTION

There has been an alarming rate of increase in the price of building materials in the recent past, this has necessitated government, private and individuals to go in research for locally sourced materials to supplement (replace-fully or partially) the conventional materials. It is in this regard that the researcher intends to carry out this study with a view to partially replace cement in concrete with rice husk ash which is locally available. The whole concept of this idea is to ensure that an average working class citizen of Nigeria will be able to own a house. Concrete is a composite material which consists essentially of a binding medium, within which are embedded particles or fragments of a relative inert filler in Portland cement. Concrete, the binder is a mixture of Portland cement, possibly additional cementitious materials such as fly ash and water; the filler may be any of a wide variety of natural or Artificial, fine and coarse aggregates; and in some instances, an admixture (Moxie, 2001).Concrete is presently one of the most popular materials used in building construction and Other civil engineering works. When reinforced with steel, it has a higher capacity for Carrying loads. Concrete being a heterogeneous material, the quality of the constituents and the proportions in which they are mixed, determine its strength and other properties.

A vast majority of the cement used in construction work is the Portland cement. Portland cement is manufactured by mixing naturally occurring substances containing calcium carbonate with substances containing alumina, silica and iron oxide (ECO-CARE, 2005).

ASTM C 618-05 defined pozzolana as siliceous or siliceous and aluminous materials which in themselves have little or no cementitious properties but in finely divided form and in the presence of moisture, they react with calcium hydroxide which is liberated during the hydration of Portland cement at ordinary temperatures to form compounds possessing cementitious properties. They include pumice, tuffa, volcanic ash, diatomaceous earth, calcined clay, shales, and pulverized-fuel ash (PFA) or fly ash. By - product mineral admixtures such as fly ash, rice husk ash, and ground granulated blast furnace slag are attracting much attention as materials that not only contribute to improvement of concrete performance (for example, high strength, high durability, and reduction of heat of hydration) but are also indispensable to the reduction of energy and carbondioxide generated in the production of cement (Nagataki, 1994). ASTM C 618-05 specified that any pozzolana that will be used as a cement blender in concrete requires a minimum of 70% for silica, alumina and ferric oxide, and a maximum SO_3 content of 5%. Neville (1995) described rice husk ash as a pozzolana.

Rice Husk is the outer covering of the rice grain consisting of two interlocking, It is usually produced as a waste while processing rice through a process called threshing (Ikpong, 1993), threshing could be manual or mechanical. Rice Husk Ash (RHA) is obtained after burning rice husk in an electric furnace, which allow for accurate monitoring of the burning temperature. The burning temperature will be maintained within the range of 650-700^{0}C as this is the thermal level that produces highly reactive amorphous ash (Ikpong 1993), The colour is dependent on the carbon content of the ash.

Rice husk ash is a finely fragmented or divided particle of agricultural waste product measuring less than 11/2 [about 1/9mm] in diameter, it is obtained from removal of rice grain from shell called husk (Neville and Brooks, 2002, Varghese 2006). Several institutions have investigated the properties of RHA and found out that it contains higher proportion of silica and there has been some commercial exploitation of its pozzolanic reaction with lime. Rice Husk Ash is also described as a fine pozzolanic material, which itself is poorly cementious but can form a cementitious compound in the presence of lime and water, the pozzolanic value of RHA depends on the burning conditions. Controlled incineration of the husk to about 700^{0}C yield amorphous RHA which is highly pozzolanic (Okpala 1987).

Matawal (2005) revealed that RHA obtained from burning rice husk between temperatures of 1500^{0}C-1560^{0}C could be use in partial replacement of cement as an active addition, the ash melt to a non pozzolanic material greater than 100mm and less than 2mm. The chemical composition has been analyzed to contain SiO_2 (90%) Al_2O_3 (1.5%), Fe_2O_3 (0.5%), C (0.75%) remaining 3% or more is a mixture of CaO, MgO, K_2O and NaO. Okpalla (1987) showed that at 40% partial replacement of cement, Rice Husk Ash (RHA) produced a concrete with the same strength as plain Ordinary Portland Cement (OPC) concrete. Mbachu and Kolawole (1998) examined the influence of coarse aggregate on the drying shrinkage and elastic moduli of concrete with OPC partially replaced with RHA. Results showed that OPC/RHA concrete cast with quarry granite as coarse aggregate exhibited the least drying shrinkage over time and also gave the highest values of elastic moduli when compared with river gravel. On high performance concrete incorporating Rice husk ash as a supplementary cementing material, Zhang and Malhotra, (1996) reported that rice husk ash concrete had excellent resistance to chloride ion penetration and higher compressive strengths at various ages up to 730 days compared with that of the control concrete. Mahmud, Majuar, Zain and Hamid

(2005) reported that with 10 % replacement of cement with Rice husk ash, high workability rice husk ash concrete mixtures in the range of 200-250 mm slump and having 28 days strengths of 80 MN/m2 can be produced. They concluded that Rice husk ash is just as good as Condensed silica fume in producing strength concrete of Grade 80 and can also be produced at a much lower cost the condensed silica fume, The main objective of this study is to investigate the suitability of Rice Husk Ash (RHA) produced by open burning as partial replacement for cement in concrete.

MATERIALS AND METHODS

The materials used in the tests were Rice Husk Ash, ordinary Portland cement (Dangote Brand), Sand, Granite (19mm coarse aggregate) and Water. The tools used were moulds (150 mm x 150 mm size), shovels, hand trowels and head pans. The Rice Husk was obtained from a milling farm, in Gidan Kwano village in Minna, Niger State. The ash was obtained by burning the Rice Husk on an iron sheet in the open air under normal temperature, during the burning the husk was not tampered with to avoid the formation of crystalline ash which is less reactive to lime (Smith, 1987). The idea of burning them in a furnace was dropped because it will be time-consuming and uneconomical for most people especially those in the rural areas. The burnt ash was passed through a BS sieve (75 microns). The portion passing through the sieve would have the required degree of fineness of 0.063mm and below while the residue was thrown away (Mbachu and Kolawole, 1998). The batching of the concrete materials was done by volume. The mix proportion used for this work was 1:2:4. The proportions of cement to ash in the concrete were 100:0% as control, 90:10%, 80:20%, 70:30% and 60:40% respectively. The fine aggregate used was sand. The sand used was river sand, free from deleterious substances obtained from Bosso area of Minna; the coarse aggregate used was granite obtained from Tri-Acta quarry in Minna with maximum size 19mm (3/4in) specified. The concrete materials cement, aggregates and ash were mixed by hand with a water/cement ratio of 0.55 by weight. The materials were mixed together thoroughly by stirring to form a Uniform mass. The moulds were cleaned with engine oil to prevent the development of bond between the mould and the concrete and permit easy stripping. The freshly mixed concrete was scooped into the mould. Each mould was filled in three layers with the concrete; each layer was rammed 25 times with a tamping rod. Then the concrete cubes in the moulds were left in the open air for 24 hours. For each of the cement: ash proportions, three cubes of concrete were cast. Therefore, a total of 90 cubes were produced for testing. Stripping of the concrete cubes from the mould was carefully done after 24 hours of the concrete setting under air. Curing of the concrete cubes was done by complete immersion in a clean curing tank measuring 1.5 m x 1.5m filled with tap water only for periods of 7, 14, 21 and 28 days respectively. Chemical analysis of RHA was carried out at National Metallurgical Development Centre, Jos. The X-ray Analyzer together with Atomic Absorption Spectrophotometer (AAS) were employed for the analysis except for Sulphur Oxide, Sodium and Potassium Oxide where the Flame Analyzer was used, gravimetric method was employed in the determination of the Carbonate and Hydrogen Carbonate. For compacted bulk density, the container is filled in three stages, each third of the volume being tamped 25 times with a 16 mm diameter round-nosed rod. The overflow is removed. The net mass of the aggregate in the container divide by its volume represents the density. Before crushing, the cubes were brought out of the water and kept for about 10 minutes for most of the water to drip off. They were then weighed on a weighing balance and then taken to the crushing machine in accordance with BS 1881: Part 116 (1983). The cubes experienced cracks due to failure in their strength as a result of the load applied by the crushing machine.

RESULTS AND DISCUSSIONS

The results contained in Table 1 shows that RHA contains some of the elements (oxides) found in both pozzolana and ordinary Portland cement. When compared with the composition of ordinary Portland cement, the percentage of CaO in ordinary Portland cement was far higher than that of the Rice Husk Ash. These compounds are known to have cement properties that would be beneficiary to the concrete. However, the total percentage of Iron Oxide, Silicon Oxide and Aluminum Oxide is a little above the minimum of 70% specified for pozzolanas (ASTM 618, 2005).

Table 1: Chemical content of RHA and OPC used for the research

Oxide	RHA	
Fe_2O_3	0.95	
SiO_2	67.30	
Al_2O_3	4.90	
CaO	1.36	
MgO	1.81	
Na_2O		
K_2O		
P_2O_5		
TiO_2		
SO_3	0.75	
L.O.I*	17.78	-
% of Essential Oxides (Fe_2O_3+SiO_2+Al_2O_3)*	73.15	

Sources: National Metallurgical Development Centre Jos .

Where: RHA= Rice Husk Ash, OPC = Ordinary Portland Cement

From the results shown in Table 2, it can be seen that for the control (0% ash content) and for each cement:ash combination, the compressive strength increases as the age of the concrete increases. This is due to hydration of cement. The control had the highest rate of early strength development. FAO, (1986) reported that cement blended with pozzolanas would produce 65 to 95 % strength of OPC concrete in 28 days. Further, they reported that their strength normally improves with age since pozzolanas react more slowly than cement due to different composition and at one year about the same strength is obtained. This behaviour was confirmed by Sideris and Sarva, (2001) and Sengul Tasdemir and Tasdemir (2005) was similar to the pattern of this study. In their study, Sideris and Sarva, (2001) reported that the replacement of ordinary Portland cement by a pozzolanic material usually has beneficial effects on cement's durability at ages up to 1.5 years. The above account for the low strength values recorded with the addition of ash in the mixture. At age 28 days, the respective compressive strengths were 27.21MN/m^2, 24.07MN/m^2, 22.06MN/m^2, 20.37MN/m^2, and 19.00MN/m^2. The results show that for the same age, the compressive strength decreases as the proportion of ash increases. This is because the ash possesses little cementing properties compared to a Portland cement.

According to BS 8110 (1985), a grade 25 concrete of 1:2:4 mix design without any blending of the cement should have acquired strength of 13.5 N/mm^2 within the first seven (7) days of wet curing and 25 N/mm^2 within 28 days. , The 10% RHA sample was found to show a promise of attaining similar strength as the control mix at a later curing age having progressed to about 90% (i.e. 24.07N/mm^2—89%) of the design Strength by the 28-day,see Table 3. Based on the above and the result obtained from this work, OPC/RHA ratio of 70/10 would be suitable for concrete. From the results in Figure 1, it can be seen that for the control (0% ash content) and for each cement ash ratio, the density decreases with age of curing. This is expected because as the concrete hardens it uses up water in hydration, and the products of hydration occupy less space than the original water and cement (Neville, 1995). Also the results show that for the same age, the bulk density decreases as the proportion of ash increases. This is expected because ordinary Portland cement has a higher specific gravity than ash.

Table 2: Means Compressive Strength Corresponding To Hydration Period And Percentage of Rice Husk Ash (RHA).

RHA Content (%)	0	10	20	30	40
			STRENGTH (N/mm^2)		
Age (days)					
7	18.30	16.75	15.03	14.72	12.88
14	22.93	22.03	17.09	16.04	13.67
21	24.99	22.98	18.98	17.22	16.01
28	27.21	24.07	22.06	20.37	19.00

Table 3: Compressive Strength as Percentage of 28-Day Strength of Rice Husk Ash (RHA).

RHA Content (%)	0	10	20	30	40
			STRENGTH (N/mm^2)		
Age (days)					
7	67.25	61.56	55.24	54.10	47.34
14	84.27	80.96	62.81	58.95	50.24
21	91.84	84.45	69.75	63.29	58.84
28	100.00	88.46	81.07	74.86	74.86

Source: Author's work, 2011.

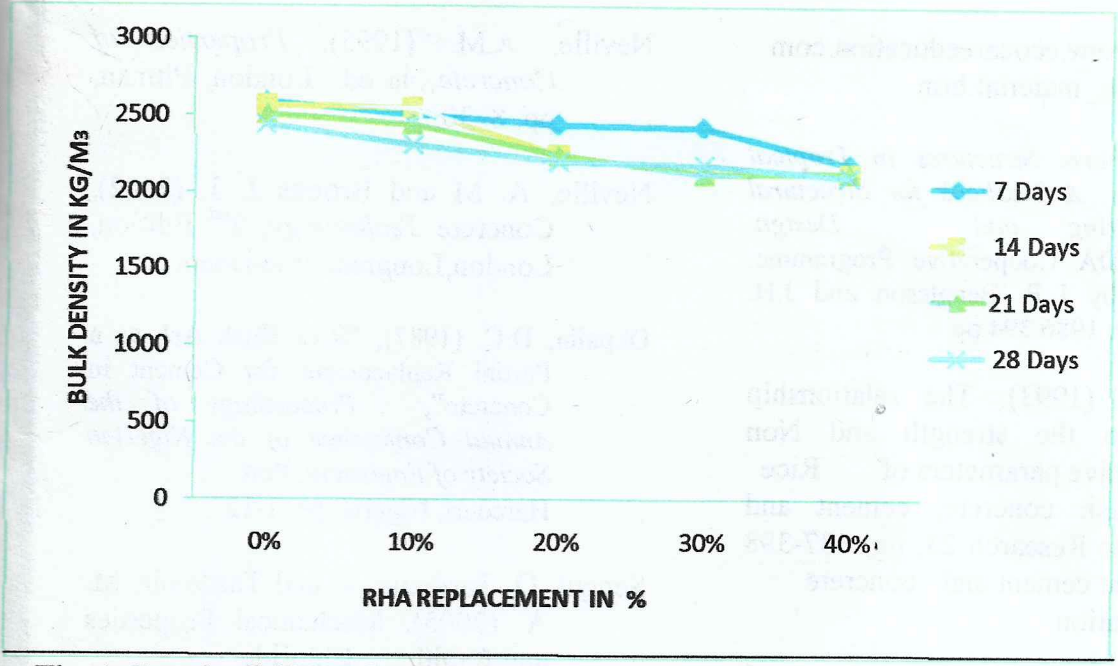

Fig. 1: Density Of Rha Concrete

CONCLUSION

The result of the research work presented demonstrate that although the RHA/OPC concrete only had compressive strength values ranging between 74.86 to 100% of the 28-day strength (for 40% to 10% RHA), the 10% RHA sample was found to show a promise of attaining similar strength as the control mix at a later curing age having progressed to about 90% (i.e. 24.07N/mm^2—89%) of the design Strength by the 28-day. The introduction of rice husk ash (RHA) presents a good tendency of pozzolanic activity, while research studies towards boosting the property of the rice husk ash sample from the study area will be a welcome development in continuing the search for alternatives. The RHA/OPC concrete can at the moment be adopted for construction of masonry walls and simple foundations. Further studies should be concentrated on boosting the total $Al_2O + Fe_2O_3$ content of the RHA sample from Gidan Kwano village where a large quantity of rice husk is being produced which is littering the environment and could be used as supplements to cementitious material. The RHA/OPC concrete sample can be investigated for longer hydration periods such as 56, 90, and 120 days to ascertain its pozzolanic tendencies.

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