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

the possibility of knowing the properties of abundantly available local 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 Gallenkanp 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+SiO+Al2O3)*	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

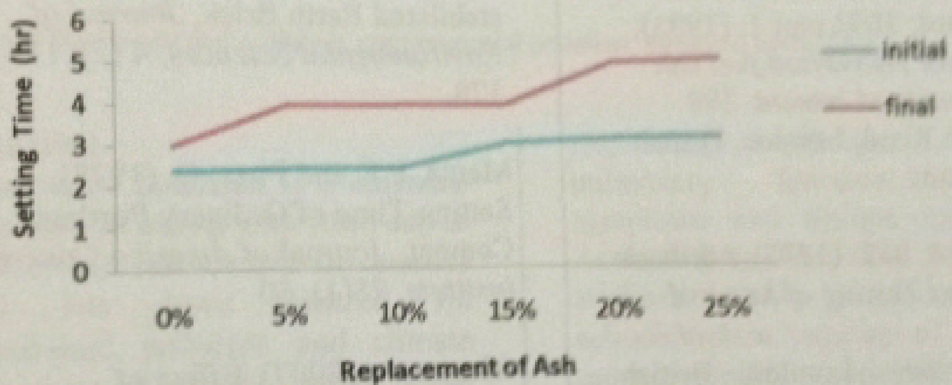

Fig 1: Setting Time of Cement Paste with Cassava peel Ash (CPA)

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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