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Effects of Cassava Peel Ash (CPA) as Alternative Binder in Concrete

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Abstract: *This work reports the outcome of an experiment carried out by using cassava peel ash (CPA) of varying quantities to partially replace cement in concrete work. The experiment was carried out by partially replacing cassava peel ash (CPA) of 0 to 20 percent by weight of cement at 5% interval. The concrete was batched with a mix ratio of 1:2:4. The cubes produced were allowed to cure for 7 -28 days. Compressive strength test was conducted on the samples at interval of 7 days. Slump test and setting time of the concrete cubes were conducted. The result obtained showed that compressive strength of the concrete increased with increase in length of curing age, but decreased as the percentage of CPA increases. However, the strength still remained in the allowable range of workability for concrete in line with the British standard. CPA replacement of 5 - 15 percentages was found to be suitable considering the strength and safe use of the concrete. It was concluded that CPA replacement of 5%, 10% and 15% showed no significant loss in strength compare to the control sample and is stable and could be acceptable in most concrete. At the long run Cassava peeling that currently constitutes waste concern in South Western Nigeria can best be managed through alternative use.*

Keywords: *Cassava Peel ash (CPA), Compressive strength, Pozzolan, Slump, Cement*

1. INTRODUCTION

The use of pozzolanic materials is found in many ancient civilizations. Pozzolans were used to improve the properties of lime, and many structures are still extent as a testament to the durability of lime–pozzolan mortars and concrete. More recently, in Europe and the USA, there have been numerous high rise buildings, highways, dams, bridges, harbours, canals, aqueducts and sewer systems built with the use of pozzolan-cement mixtures. Ketkukah and Ndububa (2006) and some of the notable researchers who have demonstrated the use of ashes of rice husk, sugar cane straw and groundnut husk as pozzolan in concrete. They have shown that compressive strength of concrete incorporating these ashes increases while the workability is enhanced at a considerable percentage. In the works of previous researchers, the use of rice husk ash reduces the effects of alkali-silica reactivity as well as drying shrinkage. Nehdiet. al (2003) and Mehta and Monteiro (2004) reported that the performance of these materials, as pozzolans, depends on the type and amount of amorphous silica content they contain which further depend on duration and calcinations temperature. Ramezanianpour et al. (2009) suggested burning temperature of 650^{o}C for 60 minutes in the case of rice husk ash while between 800^{o}C and 1000^{o}C was used for sugar cane straw ash.

Cassava peel (CP) is a by-product of cassava processing, either for domestic consumption or industrial uses. Adesanya et al (2008) reported that cassava peel constitutes between 20-35% of the weight of tuber, especially in the case of hand peeling. Based on 20% estimate, about 6.8 million tonnes of cassava peel is generated annually and 12 million tonnes is expected to be produced in the year 2020. Indiscriminate disposal of cassava peels due to gross underutilization as well as lack of appropriate technology to recycle them is a major challenge, which results in environmental problem. Thus, there is need to search for alternative methods to recycle them (cassava peels).Salau and Olonade (2011) studied the pozzolanic potential of cassava peel ash (CPA) and their results showed that cassava peel ash possesses pozzolanic reactivity when it is calcined at 700^{o}C for 90 minutes. At these conditions, CPA contained more than 70 per cent of combined silica, alumina and ferric oxide.

This work studies workability, compressive and setting time of concrete with cassava peel ash used as partial substitute for cement.

2. Materials and Methods

2.1 Materials

This research was carried out in the campus of The Polytechnic, Ibadan. Oyo state, Nigeria.

Fig1. *Map of Ibadan, Showing Ibadan Town. Hint: Blue Dot Represents The Campus*

Source: *Google earth map. (www.googleearthmap.com)*

The major materials for this investigation was cassava peelings, cement, sand aggregate and water, while equipment used include: 150 mm x 150 mm x 150 mm concrete cube mould, Concrete crushing machine (Universal testing machine), slum test apparatus.

2.2 Methods

Cassava peels were collected from cassava peels dump site at a garri processing centres in Moniya, ibadan Oyo State, Nigeria. The ash was produced by firstly open burning (presence of oxygen) before it was calcinated (absence of oxygen) for 60 minutes at 600^0C. It was sieved, using 150 µm sieve size to produce fine ash. The chemical composition and physical characteristics of the ash are presented in Table 1. The cement used in this study was Ordinary Portland Cement with brand name *Elephant*. Its chemical composition was determined using X-ray florescence technique at Lafarge/WAPCO Cement Company. The properties of the cement are presented in Table 1. Fine aggregate used was river sand while crushed granite of maximum nominal particle size of 19 mm was used as coarse aggregate. The grading for the aggregates was done according to BS 1377 Parts 1 and 2.

2.2.1 Slump Test

The slump test for concrete was carried out following the standards given in BS 1881: 102. The concrete slump test is an empirical test that measures the workability of fresh concrete. In order to maintain standard consistency for all the concrete mixes, the slump value was kept within the range 40mm to 75mm and the water-binder ratio (w/b) to achieve this was determined for each concrete mix. The results of the w/b at different content of CPA are presented in Table 3. It is observed that the w/b increases with increase in CPA content.

A w/b of 0.60 was obtained in case of normal concrete (0% CPA) while concrete containing 5%, 10%, 15% and 20% have w/b of 0.65, and 0.70, respectively. The reason for this behaviour could be attributed to higher water absorption potential of cassava peel ash. The implication is that more water would be required to produce concrete containing CPA depending on the amount used.

2.2.2 Setting Time of OPC/CPA

The setting time of cement is the result of the hydration of Portland cement; produce microscopic mineral products that link adjacent cement grains to each other. As hydration progresses, each cement grain is bound more tightly together so that it becomes more difficult for outside force to deform the concrete. The initial and final setting times of OPC/CPA concrete mixes and the trend of variation of setting times showed an increase of both setting times with the increase of CPA content. As the CPA content is increased from 0% to 20%, the initial setting time was found to increase from 95 minutes to 140 minutes and the final setting time increased from 155 minutes to 230 minutes.

2.2.3 Compressive Strength

Compressive strength of concrete determines to a great extent the ability of structure to withstand the load imposed on it. The concrete cubes samples for 0%, 5%, 10%, 15% and 20% for 7 days were removed from the curing tank and were allowed to dry for 24hours before they were crushed with use of a Universal Compressive Strength Test Machine at the civil engineering soil laboratory. The cubes were firstly weighed with the use of a weighing balance to determine the weight of the cubes, and the cubes were placed at the compressive chamber in the Universal test machine and loads were applied on the cubes. The crushing loads were obtained when the cube specimens cracked at the impact of the loads been applied, the crushing loads obtained was then divided by the area of the cubes to determine the compressive strengths. This process was conducted for 7, 14, 21 and 28days and the values gotten were reported.

3. RESULTS AND ANALYSIS

3.1 Chemical Composition of OPC/CPA

The chemical composition of both the cement and CPA is presented in Table4.1. It is observed that the dominant oxide in the cement and CPA are CaO and SiO2 respectively. CaO is the main source of binding and hardening compound in cement, when reacted with water (hydration reaction), which is very low in CPA. But, the SiO2 in CPA reacts with Ca(OH)2 (by product of cement hydration) to produce more binding property (Pozzolanic reaction). The advantage of reduction in the consumption of cement leading to reduction in the greenhouse effects of cement usage is being exploited by the use of pozzolan in concrete production.

Table3.1. *Chemical Composition of Cement and Cassava Peel Ash (CPA)*

Chemical composition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	LOI
Cement	20.80	3.10	2.50	64.50	1.70	0.23	0.85	2.50	3.40
CPA	36.79	7.57	2.23	8.20	2.9	1.37	18.74	1.52	15.10

Source: *By Musbau Salau, (2012)*

3.2 Slump Test

The results of the w/b at different content of CPA are presented in Table 3. It is observed that the w/b increases with increase in CPA content. A w/b of 0.60 was obtained in case of normal concrete (0% CPA) while concrete containing 5%, 10%, 15% and 20% have w/b of 0.65, and 0.70, respectively. The reason for this behaviour could be attributed to higher water absorption potential of cassava peel ash. The implication is that more water would be required to produce concrete containing CPA depending on the amount used. However, the amount of water in a concrete matrix is a major factor that influences most engineering properties of concrete, it is expected that the inclusion of cassava peel ash would have effect on the performance of concrete.

Table3.2.1 *Slump Test of concrete of different cassava peel ash (CPA)*

CPA content (%)	Slump (mm)	Comment
0	40	TRUE TEST
5	48	TRUE TEST
10	57	TRUE TEST
15	70	SHEAR TEST
20	75	COLLASPE TEST

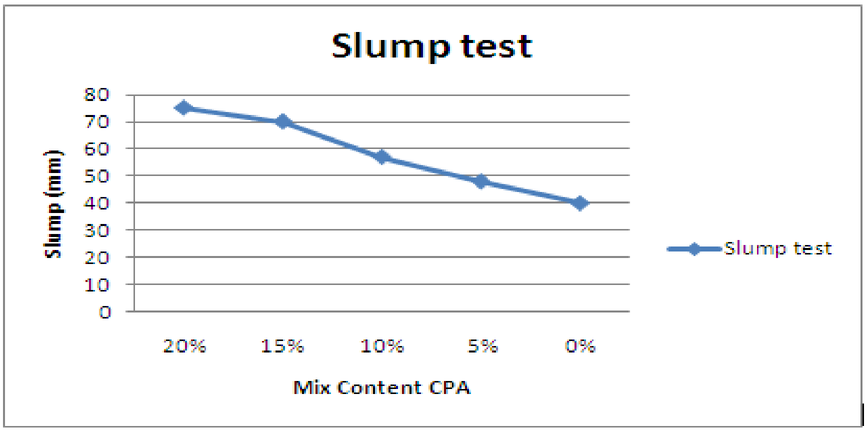

Fig2. *Slump test charts*

3.3 Compressive Strength

The compressive strength of cement-CPA concrete, irrespective of the amount of CPA in the mixture, increases as the age of curing increases. However, the compressive strength decreases as CPA content increases. This is more pronounced at the early age especially at age 7 days (Table 5). For normal concrete, 0% CPA, the compressive strength at 28-day is 28N/mm^2 while that of 5, 10, 15 and 20% are 14.82, 13.85, 14.75 and 9.85N/mm^2 respectively representing decrease. With the exception of 20% CPA replacement of cement, it can be observed that the difference in strength between the normal concrete and CPA blended concrete reduces progressively with age with 5, 10 and 15% CPA replacement levels at 28-days. This also indicates that CPA has potential to contribute to late strength development when not more than 5% by weight of cement is used. This behaviour suggests that CPA possesses pozzolanic characteristics.

Table 3.3.1 *Summary of Compressive Strength Result*

CPA (%)	7 days	14 days	21 days	28 days
0	12.27	16.85	20.45	23.48
5	10.39	13.48	17.47	19.55
10	9.60	12.22	14.90	16.70
15	8.23	10.76	12.84	14.88
20	6.53	8.62	10.37	12.71

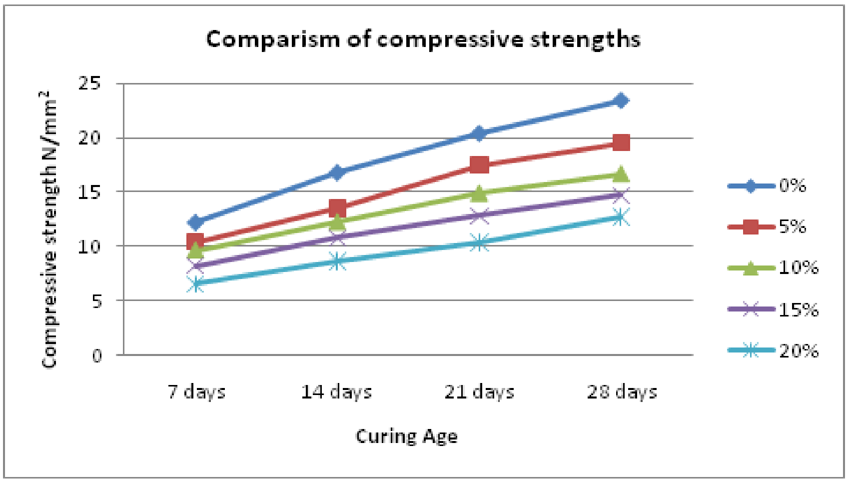

Fig3. *Compressive strength Chart*

3.4 Setting Time

The initial and final setting times of blended cement mixes are presented in Table3.4.1. The trend of variation of setting times shows an increase of both setting times with the increase of CPA content. As the CPA content is increased from 0% to 20%, the initial setting time was found to increase from 95 minutes to 140 minutes and the final setting time increased from 155 minutes to 230 minutes. This is logical as the increase of CPA content reduces the cement content in the mix and also decreases the surface area of the cement. As a result hydration process slows down causing setting time to increase.

The slow hydration means low rate of heat development. This is of great importance in mass concrete construction and it is there that CPA/OPC cement can be mostly used.

Table 3.4.1 *The Initial and Final setting time (Mins) of CPA/OPC concrete*

Mix consistuent	Setting Time	
	Initial (Mins)	Final (Mins)
0%	95	155
5%	105	170
10%	115	185
15%	125	205
20%	140	230

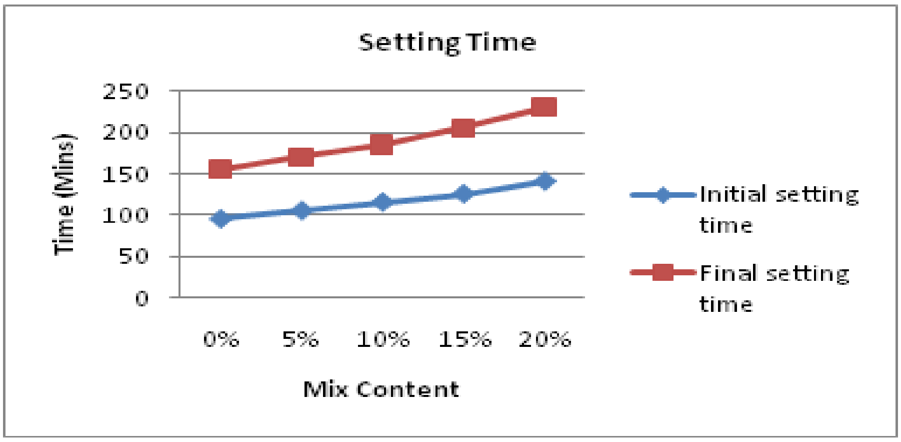

Fig4. *The Initial And Final Setting Time (Mins) of CPA/OPC Concrete*

4. Conclusions

This study demonstrates how the use of appropriate technology can transform abundantly available, cheap agricultural waste which could be potential environmental hazards into a natural resource and hence, can be used in the construction of masonry walls, simple concrete composites and simple foundations. However, the compressive strength decreases as CPA content increases and this is more pronounced at the early age especially at 7 days (Figure 11). For normal concrete with 0% CPA, the compressive strength at 28 day is 23.48N/mm^2 while that of 5, 10 and 15% are 19.55, 16.70 and 14.88N/mm^2 respectively representing a decrease of 13.46, 11.21 and 9.57% respectively. But at 7 days the compressive strength of concrete at 0% CPA is 12.39N/m^2 with 26.09% increase and while 5, 10 and 15% are 10.39, 9.0 and 8.23N/mm^2 with a percentage increase of 22.09, 20.42 and 17.50% respectively. It can be observed that the difference in compressive strength between normal concrete and CPA content reduces progressively with age with 5, 10 and 15% CPA replacement levels at 28 days. And this also indicates that CPA has potential contribution to late strength development when not more than 15% by weight of cement.

The following conclusions are drawn:

- Compressive strengths increases with age but reduces with increase in CPA content in the mix especially when more than 15% CPA is used.
- As CPA content increases, water-binder (w/b) to achieve workable concrete also increases. It is suggested that an optimum w/b ratio of 0.7 may be appropriate
- Concrete made from cement (OPC) – Cassava peel ash possesses relative low compressive strength.
- Concrete with CPA consistuent of 5%, 10% and 15% is still stable and could be acceptable in most concrete work.
- CPA replacement of 5%, 10%and 15% in concrete with OPC showed no significant loss in strength compared to the control sample.

REFERENCES

[1] Adesanya, O.A, Shittu, L.A, Adesanya, R.A. (2008). ‘‘ The internet journal of Microbiology’’. Vol.5.No.1.Pp.25-35.
[2] BS 1377. Methods of Test for soils for Civil Engineering Purposes; BSI: London, UK, 1990; Part 1 and 2.
[3] BS 1881 – 102; 1993. Method for determination of slump.
[4] British Standard Institution, (1983). Method for determination of compressive strength of concrete cubes, BS 1881: Part 116, London, British Standard Institution.
[5] Ketkukah, T.S. and Ndububa, E.E. (2006). ‘‘ Groundnut Husk Ash (GHS) as a pozzolana material in mortar’’. International Journal of Science and Technology Research, Vol.3, No.2. Pp.209-214.
[6] Monteiro, J.M, and Mehta, P.K, (2004). ‘’Concrete, Microstructure, Properties and Materials’’. University of Technology Press.
[7] Ramezaunianpour, A.A, Medhi, K.M. and Ahmadibeui, G. (2009). ‘’The effect of Rice Husk Ash and mechanical properties an durability of sustainable concretes’’. International Journal of Civil Engineering.Vol.7.No.2.Pp 32-45.
[8] Salau, M.A.and Olonade, K.A. (2011). ‘’Pozzolanic potentials of cassava peel ash’’. Journal of Engineering Research.Vol.7.Pp.9-12
[9] Salau, M.A.and Olonade, K.A. (2011). ‘’Pozzolanic potentials of cassava peel ash’’. Journal of Engineering Research.Vol.7.Pp.9-12
[10] Wilson, J.W. and Ding Y.C. (2007). ‘’A Comprehensive Report on Pozzolanic admixtures, with cement industry. Pp.16-30.