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STRUCTURAL VALUE OF BAMBOO LEAF ASH AS A POZZOLANIC MATERIAL IN A BLENDED PORTLAND CEMENT

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ABSTRACT

The paper investigates the pozzolanic properties of bamboo leaf ash (BLA) in in a blended portland cement. The structural value of the bamboo leaf ash in a blended Portland cement was evaluated with consideration for its suitability in concrete. Varied percentage of bamboo leaf ash at 0%, 5%, 10%, 15%, and 20% replaced cement in 1:2:4 concrete mix. Sieve analysis of the BLA, fine aggregate and coarse aggregate were carried out. The workability of the mix was determined through slump; standard consistency test was carried on the cement and BLA at a replacement level of 5% to determine the strength and soundness of the cement in comparison with BLA. The chemical composition of BLA in comparison with ordinary Portland cement (OPC), while tests to determine the pozzolanicity of BLA such as determination of liquid phase of Ca2+ and pozzolanic reactivity in suspension at a varying temperature of 30oC and 75oC were carried out. Compressive strength of hardened cured (150 x 150 x 150) mm concrete cubes at 7days, 14days, 21days and 28days were tested. The results showed that at 5% BLA, the compressive strength was 14.67N/mm2 at 28 days curing. This research showed that up to 10%-15% replacement of cement with BLA is feasible for lightweight and mass concrete.

KEYWORDS: Pozzolanic, Bamboo Leaf Ash, Blended Portland cement, compressive strength.

INTRODUCTION

Composite cements are cements in which a proportion of the Portland cement clinker is replaced by industrial by-products, such as granulated blast furnace slag (gbs) and power station fly ash (also known as pulverized-fuel ash or pfa), certain types of volcanic material (natural pozzolanas) or limestone [8]. Cementitious binders are vital for all types of construction activities. The use of pozzolanas as alternatives for the commonly used Portland cement have been (re) introduced in the last few decades for cost either reduction, performance, durability or environmental reasons. One way is to use certain low cost materials for partial replacement of Portland cement clinker. Low cost materials used are industrial and agricultural by-products (wastes). Mixture of Portland cement and the above by-products are known as ‘blended cements’ or ‘composite cements’. [17]

A pozzolana is a natural or artificial material containing silica in a reactive form. By themselves, pozzolanas have little or no cementitious value. However, in a finely divided form and in the presence of moisture they will chemically react with alkalis to form cementing compounds. [8]. Pozzolanas must be finely divided in order to expose a large surface area to the alkali solutions for the reaction to proceed. Examples of pozzolanic materials are volcanic ash, pumice, opaline shales, burnt clay and fly ash. [8] The silica in a pozzolana has to be amorphous or glassy, to be reactive.[4] Fly ash from a coal-fired power station is a pozzolana that results in low-permeability concrete, which is more durable and able to resist the ingress of deleterious chemicals. [8]

Different agricultural waste products have been considered to be useful as partial replacement up to certain percentage replacement, these wastes include but not limited to the following, rice husk ash,[6] corn-cob ash [16]., saw dust ash[9], pawpaw leaf ash [9] etc.

Investigation carried out by [24] discovered and established BLA as a pozzolanic material capable of replacing OPC up to 20% and the hydration properties increases with increase in age.

Bamboo leaf ash as investigated by [17] revealed that BLA is a pozzolanic agricultural wastes due to it high silica content, in a separate paper of [6] they found that rice husk ash react best when heated and burnt at a temperature of 500ºC for two hours, while [17][24] revealed that 600ºC for 2hrs is the best condition to produce ash from bamboo leaf. In a bid to convert and make use of locally available materials for the production of concrete for sustainable construction, the influence of temperature (high or low) on the attainment of strength in Bamboo leaf ash blended cement is important to be investigated to know the amount and duration of heat the concrete produced using BLA would before eventual collapse.

EXPERIMENTAL PROCEDURES

MATERIALS

The materials used for this research were bamboo leaf ash (Fly ash), Portland cement conforming to BS 12, Sand (Fine aggregate), Granite (Coarse aggregate) and clean and deleterious-free water. The bamboo leaves were fetched in the campus of Federal polytechnic Ado-Ekiti (latitude 7.5º 85' 81''and longitude 5.3º 01' 06'') Ekiti State Nigeria. They were sun-dried and later burnt in a muffle furnace at temperature of 600ºC calcining temperature for 2 hours to obtain the ash, at Federal University of Technology, Akure, which was later subjected to sieve analysis at Soil laboratory of Civil Engineering department to determine the particle size distribution and the amount passing 75µm sieve used for the concrete mix (tables 2-4). Chemical analysis of BLA and OPC to reveal their chemical compositions as presented in table 1.0, while pozzolanic reactivity of BLA and OPC were done in Chemistry laboratory of Science Laboratory Technology department, School of Technology, Federal Polytechnic, Ado-Ekiti.

METHODS

Pozzolanic reactivity in suspension

100ml of saturated solution was mixed with 5g of BLA and stirred magnetically.10ml of the solution was filtered at different interval time, (30, 60,90 and 120,minutes) respectively was filtered against N_4HCL using phenolphthalein as an indicator from the value the amount of $Ca(OH)_2$ reacted with BLA was recorded (Table 8). The experiment was performed at room temperature (30ºC and 75ºc) the similar process also applicable to OPC. [24]

Analysis of Liquid Phase for Ca^{2+} Ions.

2.5g of OPC and BLA sample were taken and mixed with 20ml water (w/s = 2.0) and liquid was filtered at different interval of time and titrate against standard Ethylenediaminnetra-Acetate "EDTA SALT" solution. Care was taken to avoid carbonation. The test was carried out in 10 minutes interval for each sample. The result is as presented in table 9. [24]

Physical properties of Cement and BLA

Setting time and standard consistency were tested using the Vicat apparatus and they were performed in accordance to [5]. The result is as presented in tables 7 and 5 respectively.

Slump Test

Portland cement was partially replaced by bamboo leaf Ash (BLA) in a mix of 1:2:4 to determine the workability of the concrete and other tests including the determination of compressive strength for 7, 14, 21 and 28 curing days at different mix proportions. These were carried out according to [5] to achieve the desired result.

Compressive strength test

The compressive strength tests, on the samples were conducted in concrete laboratory, Civil Engineering Department, Federal Polytechnic, Ado-Ekiti. The mix ratio used was 1:2:4 at different nominal replacement of OPC with BLA and water cement ratio of 0.5 by weight. A total of 36 cubes were produced and cured, for each replacement level, three test cubes were casted and the average found to represent the entire samples. The cubes were tested for compressive strength after 7, 14, 21 and 28 days curing.

RESULTS AND DISCUSSION

Chemical Analysis of Bamboo Leaf Ash (BLA)

Chemical analysis was carried out on samples of BLA and ordinary Portland cement (OPC) to reveal and compare their composition, and the result is as shown in Table 1. The percentage composition of the constituent compounds in the BLA is compared to that of typical ordinary Portland cement (OPC). The results show that BLA contains most of the compounds known to have binding properties necessary for concrete work. The percentage composition of CaO

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and SO_3^{2-} found in the BLA was found to be less than that in the OPC. The total percentage of iron oxide (Fe_2O_3) silicon (IV) oxide, (SiO_2) and aluminum oxide (Al_2O_3) is found to be more than the minimum of 70% specified for pozzolanas by [2].

Table 1: Chemical composition of BLA and OPC

Constituents	*Percentage (%) (BLA)*	*Percentage (%) (OPC)*
(SiO_2)	*75.69*	*20.62*
(Al_2O_3)	*3.64*	*3.32*
(Fe_2O_3)	*5.06*	*5.32*
(*CaO*)	*6.74*	*62.59*
(*MgO*)	*3.74*	*3.90*
(TiO_2)	*2.05*	*1.08*
(K_2O)	*0.35*	*1.21*
(Na_2O_3)	*0.12*	*0.98*
LOI	*2.71*	*1.12*

Particle Size Distribution

Sieve analysis was carried out on 300g of river sand sample, 210g of BLA, 905g of coarse aggregate. The fine aggregate passed through 5mm sieve as recommended. Before the sand was used, it was dried to remove the moisture content so as not to increase the water content in the concrete mix and the results shown in tables 2 and 3. The results revealed the sand sample was well graded falling into zone 2 near border of zone 1, which is very appropriate for concrete work in accordance with [5] test sieve.

Table 3.0: Particle size of Bamboo Leaf Ash

Sieve sizes	**Weight retained {g}**	**Amount retained {%}**	**Amount passed {%}**
4.75mm	**9.0**	**1.8**	**98.2**
2.36mm	**17.8**	**3.6**	**94.6**
1.18mm	**55.5**	**11.1**	**83.5**
600microns	**129.8**	**26.0**	**57.5**
300microns	**100.2**	**20.0**	**23.2**
150microns	**93.6**	**18.7**	**4.5**
75microns	**10.1**	**2.0**	**2.5**

Table 4.0: Particle size of Fine aggregate

Sieve sizes	**Weight retained {g}**	**Amount retained {%}**	**Amount passed {%}**
9.50mm	**0.00**	**0.00**	**100.00**
4.75mm	**0.00**	**0.00**	**100.00**
2.36mm	**412.15**	**41.22**	**58.78**
1.18mm	**504.25**	**50.43**	**8.75**
600microns	**80.40**	**8.04**	**0.31**
300microns	**3.10**	**0.37**	**0.00**
150microns	**0.00**	**0.00**	**0.00**
75microns	**0.1**		

Table 3.0: Particle size of coarse aggregate.

Sieve sizes {mm}	Weight retained {g}	Amount retained {%}	Amount passed {%}
25	0.00	0.00	100.00
20	39.30	4.37	95.63
12.5	409.54	45.50	50.13
9.5	354.70	39.36	10.77
4.75	57.50	6.39	4.38
2.36	37.70	3.80	0.58
1.18	5.70	0.58	0.00
Pan	0.06		

Standard consistency test result:

The test was performed in accordance to BS 12, and the result shows on table 5, indicates the consistency of the mix at 1:2:4 at each replacement of BLA. The consistency indicates that the maximum value of 32.5% was obtained at a penetration of 32.5mm occurring at a mix of 15%BLA replacement.

Table 5: Standard consistency test result

S/N	Control mix @ 0%	BLA @ 5%	BLA @10%	BLA @15%	BLA @20%
Consistency	30%	31.5%	32.00%	32.5%	32.4%
Depth of penetration	33.58	33.28	34.00	32.50	33.00

Slump Test:

Table 6 below shows slump test result of the OPC/ BLA at 0%, 5%, 10%, 15% and 20% of bamboo leaf ash respectively as the more the increase in percentage of BLA, the workability of concrete decreases to that of control (i.e. 0%) the percentage of the workability decrease by 5.5 %, 10.5 %, 13.2% and 15 % for 5%, 10%, 15% and 20% respectively.

Table 6: Slump Test Result

OPC/BLA	Control mix @ 0%	BLA @ 5%	BLA @10%	BLA @15%	BLA @20%
Slump 1:2:4 mix(mm)	30.00	24.50	19.50	16.80	14.40

Setting Time Results

Table 7 below shows the result of initial and final setting time of ordinary Portland cement (OPC) and bamboo leaf ash (BLA) which indicate that initial setting time of 0% OPC is 42.26 minutes of to that of BLA is 52 %.00 minutes and the final settings time of the OPC is 140.09 minutes to that of BLA at 20 % is 201.00 minutes. The results indicate the initial and final setting time of BLA is more than OPC.

S/N	Control mix @ 0%	BLA @ 5%	BLA @10%	BLA @15%	BLA @20%
Initial setting time (min)	48.26	52.00	60.48	85.00	104.00
Final setting time (min)	140.09	152.51	169.59	193.05	201.00

Table 7: Setting Time Result

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Compressive Strength Test

Table 8 below showed the summary of the compressive strengths at different curing days for each mix, while Figure 1.0, further illustrates the inter-relationship between each percentage of cement replacement with BLA against the compressive strength for different curing days.

Table 8: Summary of Compressive Test Results

COMPRESSIVE STRENGTH N/mm²	BLA CONTENT IN %	COMPRESSIVE STRENGTH N/mm²	BLA CONTENT IN %	COMPRESSIVE STRENGTH N/mm²	BLA CONTENT IN %	COMPRESSIVE STRENGTH N/mm²	BLA CONTENT IN %
7 DAYS		14 DAYS		21 DAYS		28 DAYS	
14.67	0	15.04	0	15.48	0	16.07	0
14.37	5	14.37	5	14.67	5	14.67	5
12.89	10	13.26	10	13.85	10	14.15	10
12.51	15	12.96	15	13.57	15	14.07	15
12.93	20	12.37	20	12.53	20	12.74	20

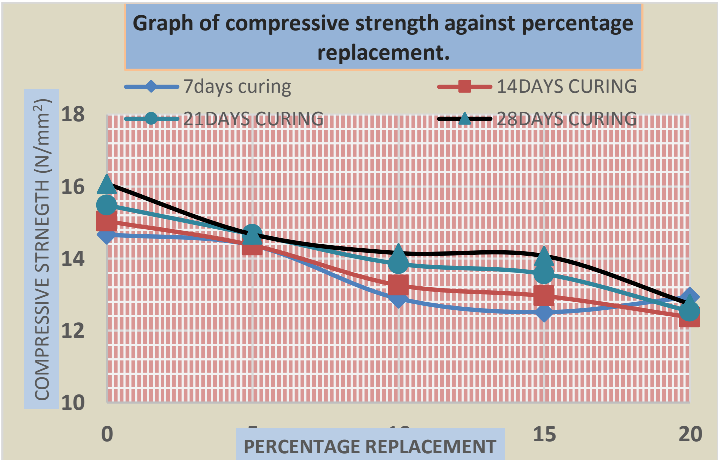

Fig. 1.0: Graph of Compressive strength against percentage replacement

Pozzolanic Reactivity in suspension

From the result presented in table 9 and figure 2.0, the pozzolanic reactivity of BLA reduces with increase in time up until 90 minutes at a temperature of 30ºC, while for 75ºC temperature pozzolanic reactivity in suspension increases continuously over the period under consideration. This shows the effect of high temperature on the gain of strength of concrete.

Table 9: Pozzolanic Reactivity in Suspension

	30⁰C (Amount of C-H reacted) (g)		75⁰C (Amount of C-H reacted) (g)	
TIME (MINUTE)	BLA	OPC	BLA	OPC
0	3.80	3.50	1.60	3.40
30	2.80	2.50	1.00	3.20
60	2.10	3.30	1.70	2.78
90	0.90	3.30	2.00	2.55
120	2.00	2.20	2.50	2.00

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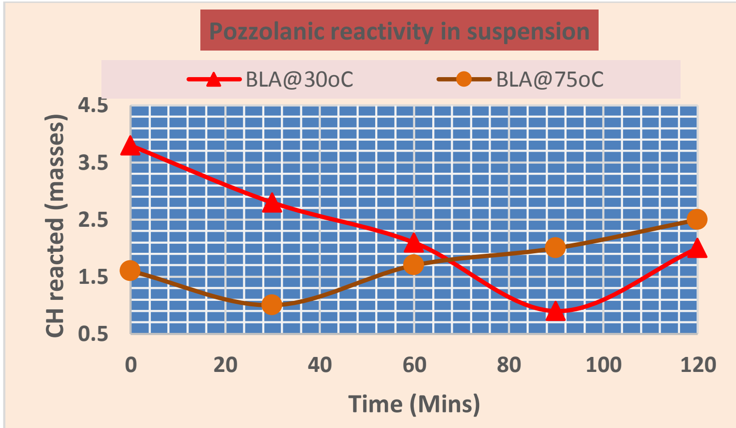

Fig.2.0: Amount of CH reacted with BLA in suspension against time at different temperature of 30°C and 75°C.

Analysis of liquid Phase Ca^{2+} Ions

As revealed in table 10 and figure 3.0, the reaction of the OPC and blended cement (BLA+OPC) with the liquid phase of Ca^{2+} ions dropped continuously over the period of hydration. This further illustrated that during hydration, more of Ca^{2+} reacts with blended mix (BLA +OPC) than OPC, a confirmation that of the pozzolanic reactivity of BLA.

Table 10: Analysis of Liquid Phase Ca^{2+} Ions

S/N	**0%**	**5%**	**10%**	**15%**	**20%**
BLA	**10.50**	**9.30**	**8.40**	**5.30**	**3.70**
OPC	**6.60**	**4.40**	**3.60**	**3.00**	**2.70**
TIME(MIN)	**0**	**10**	**20**	**30**	**40**

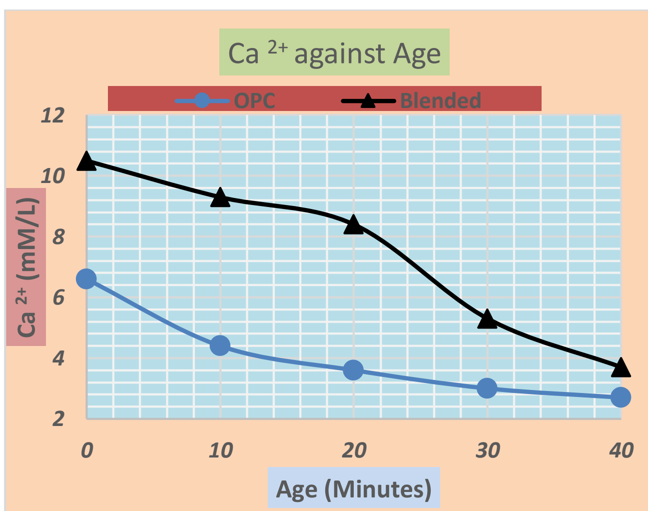

Fig. 3.0: Variation of Ca^{2+} liquid phase against hydration time.

CONCLUSION

This research showed that with increasing percentage of BLA in a 1:2:4 concrete mix replacement of OPC, compressive strength decreases. This research further showed that higher percentage BLA between 10% and 15% could be used to produce workable lightweight and mass concrete works. The calcium hydrate silicate(C-H-S) production responsible for strength gain increases with age because of high percentage of silicon (IV) oxide present in BLA and consumption of Calcium ions as evident in figure 3.0.

REFERENCES

[1] American Standard for Testing Materials, Specification for fly ash and raw or calcium natural pozzolana for use as a mineral admixture in Portland cement concrete. ASTMC 2005, 618-78.
[2] American Society for Testing and Materials, Specifications for pozzolanas. ASTM International, USA, ASTM C618, 1978.
[3] Adesanya, D. A., and Raheem, A. A. (2009b). Development of corncob ash blended cement. Construction and Building Materials, 23, pp 347-352.
[4] Antonio Price, Ryan Yeargin, Ellie Fini and Taher Abu-Lebdeh. (2014): Investigating effects of introduction of corncob ash into Portland cements concrete: mechanical and thermal properties: American Journal of Engineering and Applied Sciences 7 (1): 137-148, 2014
[5] British Standards Institution, Specification for Portland cement. London, 12-1996, pp.1-6.
[6] Deepa G Nair, Alex Fraaij, Adri A.K. Klaassen Arno P.M. Kentgens. (2008): A structural investigation relating to the pozzolanic activity of rice husk ashes, Cement and Concrete Research 38 (2008) 861–869.
[7] Dwivedia, V.N. et al "A New Pozzolanic Material for Cement Industry: Bamboo Leaf Ash, "International Journal of Physical Sciences, vol. 1, no. 3, pp. 106-111, 2006.
[8] John N, et al, Advanced concrete Technology Processes, first edition (2003), England: Butterworth Heinemann, Elsevier Limited, 2003.
[9] L.O. Ettu, J. I. Arimanwa, K. C. Nwachukwu, C. T. G. Awodiji, and A. P. C. Amanze: Strength Of Ternary Blended Cement Sand Crete Containing Corn Cob Ash And Pawpaw Leaf Ash, Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 3, May-June 2013, pp.731-735
[10] Mehta, P. K. (1997). Properties of blended cements made with sawdust ash. ACI Journal Proceedings, 74:440-442.
[11] Nair, D.G., et al, (2006) "Reactive Pozzolanas from Rice Husk Ash: An Alternative to Cement for Rural Housing." Cement and Concrete Research, V. 36, pp. 1062-1071.
[12] Nimityongskul, P., et al. (1995). Use of coconut husk ash, corncob ash and peanut shell ash as cement replacement. Journal of Ferro cement, 25(1): 35-44.
[13] Nwofor T.C., et al, Stability of groundnut shell ash (GSA)/ordinary Portland cement (OPC) concrete in Nigeria, Advances in Applied Science Research, 2012, 3 (4):2283-2287, Available online at www.pelagiaresearchlibrary.com.
[14] Okamura H. et al, (2003): "Applications of Self-Compacting Concrete in Japan," Proceedings of the 3rd International RILEM Symposium on Self-Compacting.
[15] Oladipupo, O. and O. Fetus, 2012. Strength properties of corncob ash concrete. J. Emerg. Trends Eng. Applied Sci., 3: 297-301
[16] Oluborode K.D. and Olofintuyi I.O; Strength Evaluation of Corn Cob Ash Blended Portland Cement, International Journal of Engineering and Innovative Technology,Vol. 4, Issue 12, June 2015 pp.14-17.
[17] P. Asha, A. Salman, R. Arun Kumar; Experimental Study on Concrete with Bamboo Leaf Ash, International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-3 Issue-6, August 2014
[18] Raheem, A. A. et al, (2011), "A study of thermal conductivity of corn cob ash blended cement mortar", The Pacific Journal of Science and Technology, Vol.12 No. 2, pp. 106 – 111
[19] Raheem, A. A.; et al, (2010), "Effects of admixtures on the properties of Corn-Cob ash cement concrete", Leonardo Electronic Journal of Practices and Technologies, Vol. 16, pp.13.
[20] Raju G.U, et al, (2012) Mechanical and physical characterization of agricultural waste reinforced polymer composites, J. Mater. Environ. Sci. 3 (5) (2012) 907-916, ISSN: 2028-2508, pp 907-914.
[21] Sakr, K. (2006). Effects of Silica Fume and Rice Husk Ash on the Properties of Heavy Weight Concrete. Journal of Materials in Civil Engineering, 18(3): 367-376.
[22] Shetty M.S., Concrete Technology Theory and Practice, revised multi-colour edition. 2005, India: S. Chand & Company Ltd India.
[23] Singh, N. B., Singh, V. D. &Rai., R. (2000). Hydration of bagasse ash-blended Portland cement. Cem. Concrete. Res. 30: 1485-1488.
[24] Singh, N. B., Singh, V. D. & Dwivedi., V.N. (2007): Hydration of Bamboo leaf ash blended Portland cement, Indian Journal of Engineering and Materials Sciences, pp. 69-76