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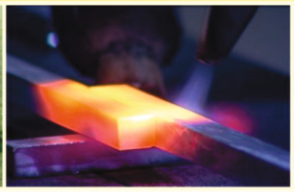


Journal of Engineering and Engineering Technology

Effects of Bamboo Leaf and Locust Beans Pod Ashes on Autogenous Shrinkage Strain and Compressive Strength of Mortar

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A B S T R A C T

Production of cement consumed large amount of energy couple with release of harmful gases like CO_2 into the atmosphere. Every effort to successfully replace its usage in construction industry is a giant achievement. So many confirmed properties of cement establish its usage as an essential construction material. Therefore any material that will partially replace it must also be tested for the various properties that make cement desirable. Therefore, this research has been able to evaluate the effects of bamboo leaf ash and Locust beans pod ash admixtures, and their mixture proportions on autogenous shrinkage strain and compressive strength of mortar specimens. The auto shrinkage strain was carried out using a cylindrical mortar specimen of 75 mm x 300 mm dimension and the volume changes were measured for the various pozzolanic concrete mixes. The compressive strength test was also carried out using 50 mm x 50 mm x 50 mm mortar specimen crushed with ELE international ADR 1500 compressive machine . The various test were carried out at 7, 14, 21 and 28 day. The results of the compressive strength test show that both bamboo leaf and locust beans pod ashes did not alter the compressive strength of their corresponding mortar significantly. The auto shrinkage results also show that both pozzolans possesses the ability to improve the auto shrinkage of these mortar mixes.

Keywords:
Autogenous shrinkage, compressive strength, pozzolans, cement, mortar

1.0 Introduction

Ordinary Portland cement is an essential material in concrete construction. It is the backbone of any concrete or mortar mixes because it is responsible for the hydration process which binds the other concrete constituents together and leads to strength development. The hydration reactions which lead to setting and strengthening of the concrete are complex and depend on the manufacturing procedures as well as the presence of admixtures in the cement used. Presence of admixture can be of different form and for different purposes. Some admixtures improve the hydration rates without altering the other cement concrete properties while some are targeted to increase the concrete strength which will in turn alter the other concrete properties. Partial replacement of cement with biogenic pozzolans is one of the newly discovered methods of cement admixture. Pozzolan which is a siliceous or siliceous and aluminous material possesses little or no cementitious value but when finely divided and in the presence of water, react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties. Pozzolans are commonly used as an addition to Portland cement to increase the long-term strength and other material properties. Pozzolans are primarily vitreous siliceous materials which react slowly with calcium hydroxide to form calcium silicates and its capability is comprised in the term pozzolanic activity (Mehta, 1987). Other cementitious materials may be formed depending on the constituents of the pozzolan (Wilson and Ding, 2007).

The use of biogenic pozzolanic materials as partial replacements in concrete manufacturing not only reduces the cost of cement and concrete production, but also, through methodical design, yields a concrete blend with tailored properties suitable for specified

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purposes. It also demonstrates a way of achieving conservation and reduction in the depletion of natural resources and conservation of energy through the use of agricultural and industrial by-products in the concrete making processes (Arum *et al*., 2013; Pavía and Regan, 2010). Past researches on bamboo leaf ash (BLA) and locust beans pod ash (LBPA) confirmed their suitability in term of chemical composition, hydration behavior, drying shrinkage, crystal and microstructural properties of their hydrated paste (Ikumapayi, 2016; Ikumapayi and Arum, 2016). It has also been reported that if ordinary Portland cement is partially replaced by BLA and LBPA, the resulting concrete will possess improved compressive strength and some other durability properties (Walker and Pavia, 2010). This research therefore verified and established further their suitability in terms of autogenous shrinkage alongside with their compressive strength.

Autogenous Shrinkage

During hydration, cement reacts with water and part of the water becomes chemically bound in the hydration products. Since the resulting hydration products possess smaller volume than the reactants (dry cement and mixing water), chemical shrinkage takes place and, if no extra water is provided, empty voids are created in the volume of the hydrating material. As water is consumed from progressively smaller pores during hydration, the relative humidity within the paste decreases. This induces a depression in the pores, which leads to a compression in the concrete solid phase called auto shrinkage (Bjontegaard, 1999; Barcelo, 2005). Autogenous shrinkage is higly significant in low water-to-cement (w/c) or high-performance concretes (HPC). The traditional, external curing used in eliminating autogenous shrinkage has not been effective in performing the task because of the inability of the surface water to penetrate the element due to a very fine structure of porosity. Moreover, external curing involves high labor costs and in practice is not always possible. Autogenous shrinkage should be limited because it may induce micro-cracking or macro-cracking and impair the concrete quality (Paillere *et al*., 1989).

Compressive strength

The compressive strength of concrete is the most common measure for judging not only the ability of the concrete to withstand load, but also the quality of the hardened concrete. Test results obtained from compressive strength tests have proved to be sensitive to changing mix materials and mix proportions as well as to differences in curing and compaction of test specimens. A test result is the average of at least two standard-cured strength specimens made from the same concrete/mortar sample cured at the same age. In most cases, strength requirement of concrete are at an age of 28 days.

2.0 Materials and Methods

Bamboo leaves and Locus bean pods were obtained from Federal University of Technology, Akure, Ondo state, Nigeria (7^{o} 15^{1} 0^{11} North, 5^{o} 12^{1} 0^{1} East) and Isua-Akoko in Ondo state, Nigeria (7.45^{o} North, 5.9167^{o} East) respectively . The dried leaves and pods were burned in a furnace at 600°C for 1hour. The other materials and equipment used are sand, ordinary Portland cement (Lafarge Elephant cement), portable water, length comparator, compressive machine, wooden moulds (50mm x 50mm x 50mm) for compressive strength, steel mould for crack pattern study and cylindrical plastic moulds (75mm diameter x 300mm) for auto shrinkage test. The properties of these materials are shown in Table 1. The particle size distribution for the sand is shown in Figure 1. The mortar mix is of ratio 1:6 of cement to sand and the water cement ratio of 0.35. The OPC was partially replaced by BLA and LBPA at 0%, 4% , 8% and 12% (Ikumapayi and Arum, 2016).

Compressive Strength Test

A total of 36 mortar cubes of 50mm x 50mm x 50mm were cast by partially replacing OPC with BLA and LPBA at 0%, 4%, 8%, and 12% (Ikumapayi and Arum, 2016). They were demoulded after 24 hours and cured for 7 days, 14 days, 21 days and 28 days (ASTM C13, 2013). The mortar specimens were crushed after the various curing days using ELE international ADR 1500 compressive machine.

Autogenous shrinkage measurement

Cylindrical specimen of 75 mm x 300 mm dimension mortar were cast as shown in Plate 1 and the volume change were measured for the various pozzolanic concrete mixes already developed in accordance with ASTM 1698-09 (2014). The measurements were taken at 14, 21 and 28 days (ASTM 1698-09, 2014)..

Table 1: Properties of Test Materials

Properties	Sand	Cement
Specific gravity	2.16	3.0
Silt or sand content (%)	16.67	
Moisture content (%)	9.04	
Diameter range (mm)		4.25×10^{4} -1.24×10^{4}

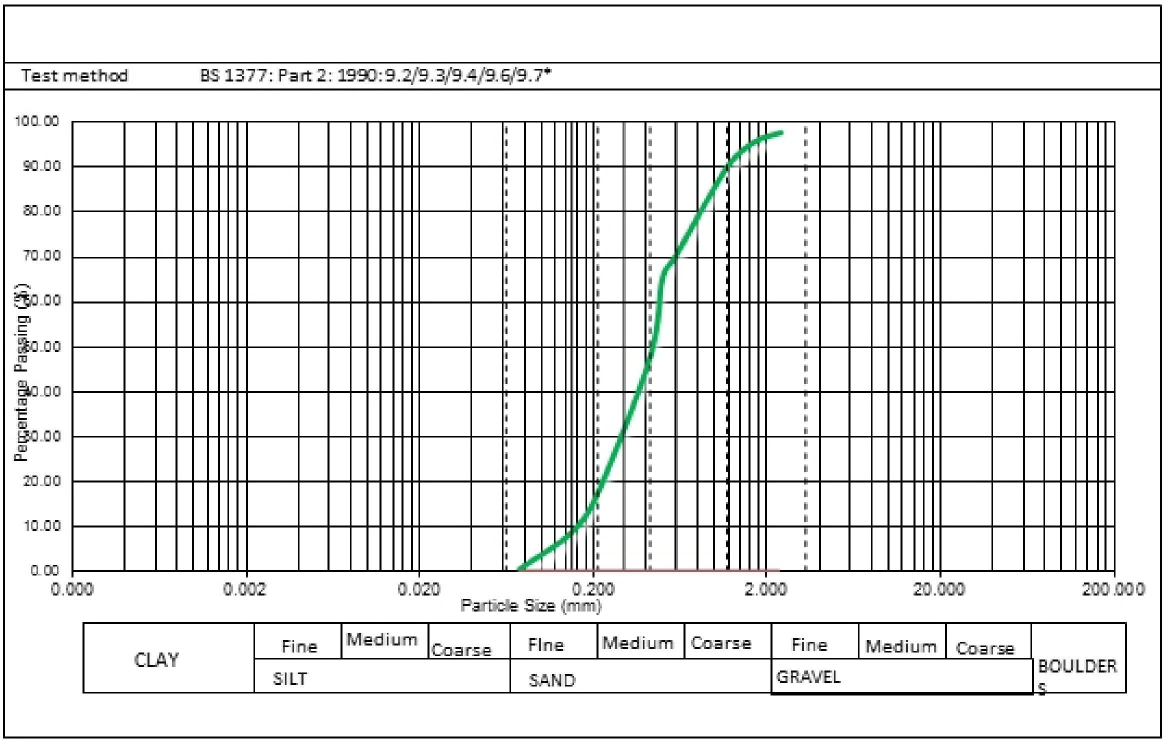

Figure 1: Particle Size Distribution for the Sand

Plate 1: Pozzolanic Concrete Mixes after Casting

3.0 RESULTS AND DISCUSSION

The results obtained for the compressive strength and the autogenous shrinkage of the various mixes are presented, analyzed and discussed.

Compressive Strength Results

The results of the compressive strength for 7 days, 14 days, 21 days and 28 days for BLA and LBPA are presented in Figure 2. The results showed that the compressive strength of OPC at early age specifically 7 days curing is higher than those of BLA and LBPA pozzolanic mortar mixes at same 7 days curing. This is an indication that hydration of the mortar mixes of OPC takes place more rapidly than those of the pozzolanic mixes. It is also observed that at 28 days curing the compressive strength of LBPA is at a higher side. The statistical analysis of these compressive strengths shown in Table 2 indicates that there is no significant different in the compressive strength of the OPC mortar mixes and that of the BLA and LBPA pozzolanic mortar mixes at any of the percentage replacement up to 12 %. This also shows that at any of these percentage replacements of OPC with BLA and LBPA the compressive strength is on the safer side.

Result of the auto shrinkage

The results of the autogenous shrinkage for the different specimens are shown in Figure 3. Auto shrinkage of the OPC mortar mixes shown in Figure 4 is higher than any of the pozzolanic mortar mixes at any percentage replacement up to 12 %. This showed the ability of BLA and LBPA to improve the auto shrinkage of these mortar mixes which will definitely improve the durability of such mixes is an indication of better durability in term of cracking. The results of the auto shrinkage of the various pozzolanic mixes analysed statistically using analysis of variance test (ANOVA) of Statistical Package for the Social Sciences (SPSS) software showed the multiple comparisons of the various OPC and pozzolanic mixes in Table 3. The Table 3 showed that there is significant different in the auto shrinkage of OPC mixes when compared to the other pozzolanic mixes at P< 0.05. This is an indication that at any replacement level up to 12% BLA and LBPA mortar are safe in terms of auto shrinkage properties.

3.0 Conclusions

From the outcome of the research, it can be concluded that :

i. BLA and LBPA can replace OPC up to 12% replacement without significantly altering the compressive strength of such mixes.

ii. The auto shrinkage properties of mortar mixe can be enhanced through the use of BLA and LBPA blended pozzolanic mixes.

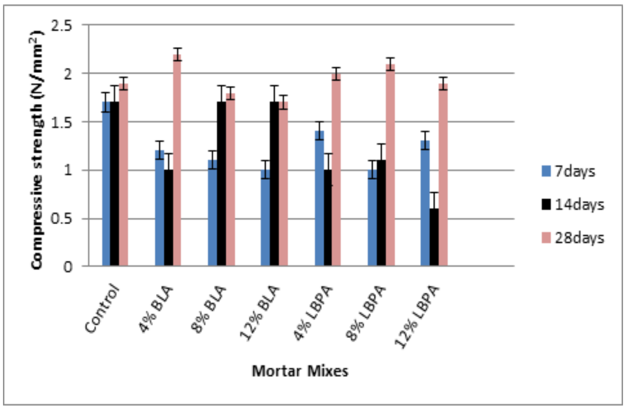

Figure 2: Compressive Strength of the Different Mortar Mixes

Table 2: LSD test for Compressive Strength of the Various Mixes at 28 days Curing. 1-OPC (control), 2-BLA (4%), 3-BLA (8%), 4-BLA (12%), 5-LPBA (4%), 6-LBPA (8%), 7-LBPA (12%)

i	j	MD (i-j)	p	Remark
1	2	-0.30	0.014	*
	3	0.10	0.365	NS
	4	0.20	0.082	NS
	5	-0.10	0.365	NS
	6	0.00	1.000	NS
	7	-0.20	0.082	NS

* Mean Difference is significant at p < 0.05, NS= Not Significant

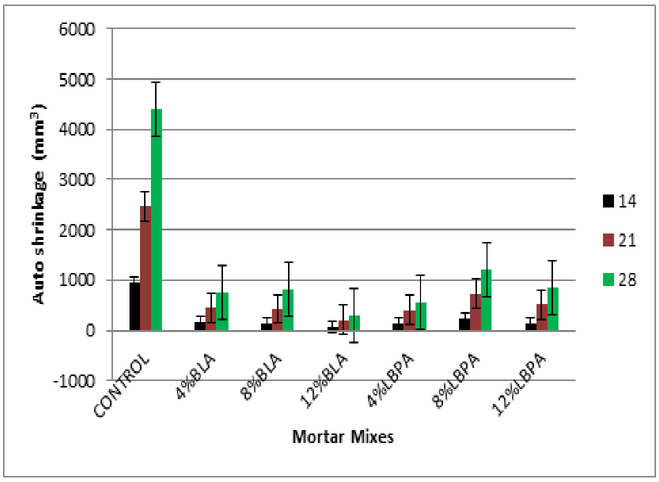

Figure 3: Influence of Pozzolans on Auto Shrinkage of Mortar Mixes

Table 3: LSD Test for Auto Shrinkage of the Various Mixes at 28 days Curing. 1-OPC (control), 2-BLA (4%), 3-BLA (8%), 4-BLA (12%), 5-LPBA (4%), 6-LBPA (8%), 7-LBPA (12%)

i	j	MD (i-j)	p	Remark
1	2	3663.10	0.000	*
	3	3591.83	0.000	*
	4	4116.10	0.000	*
	5	3849.53	0.000	*
	6	3203.00	0.000	*
	7	3552.78	0.000	*

* Mean Difference is significant at p < 0.001, NS= Not Significant

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