

Investigating the Effect of Bamboo Trunk Ash Blended Cement in Engineering Properties of Mortar

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Abstract: *The assessment of pozzolanic activity of cement replacement materials is becoming increasingly important because of the need for more sustainable cementing products. This paper was aimed to investigate the compressive strength and pozzolanic of bamboo trunk ash (BTA) as it partially replaces cement in varying percentages in mortar when silica sand is used as an aggregate. The BTA was partially used to replace cement at 0%, 5%, 10%, 15%, 20%, 25% and 30% by weight. The physical properties of silica sand was determined, Soundness, Setting time, Strength and Durability tests of ordinary portland cement (OPC) were carried out. A total of 84 mortar cubes of size 50mm x 50mm x 50mm were cast and cured in water for 7, 14, 21 and 28 days respectively. From the results obtained, compressive strength increased from 1.3MPa (0%; control sample) to 2.1MPa (25% replacement) at 28 days curing period. Partial replacement of cement with bamboo trunk ash in the mortar significantly improved its water absorption and compressive strength when compared with the control sample. In view of this, mortar produced from silica sand aggregate, OPC with a blend of bamboo trunk ash as binder could be used for bedding and jointing unit masonry.*

Keywords: Bamboo trunk ash, Ordinary portland cement, Pozzolanic, Compressive Strength

1. Introduction

Construction works globally is increasing at an alarming rate with substantial consumption of cement in large proportion, hence the need for full or partial replacement of cement so as to reduce quantity of cement being used, thereby reducing cost of construction owing to constant hike in cost of cement. Cement concrete is the most popular building material due to its satisfying performance in strength requirement and its ability to be moulded into variety of shapes and sizes. The production of cement is increasing annually by about 3% and the production of one tone of cement liberates about one tone of CO₂ to the atmosphere, as the result of decarbonation of limestone in the Kiln during manufacture of cement and the combustion of fossil fuel [1]. The global production of cement per annum is estimated at 11 billion tonnes [2] while the global demand for cement is forecast to grow by 4.7% annually [3]. In Nigeria, cement consumption growth is projected as 8.5% for 2012 to 2015 [4]. Therefore, it is necessary to search for affordable and cheaply obtainable material that could partially replace cement in concrete in order to reduce the environmental effect of cement and the cost of concrete in the construction industry. The use of waste materials as pozzolanic properties in concrete production is a worldwide practice [1]. So many pozzolans have been investigated for suitability in the production of blended cement concrete, these include rice husk ash, bamboo leaf ash, coconut shell ash, groundnut shell ash, burnt clay waste ash, saw dust ash, corn cob ash, fly ash, silica fume, metakaolin, blast furnace slag, clinoptilolite, periwinkle shell ash etc. Utodio [6] study on "Investigation of the effect of Bamboo Leaf Ash Blended cement on Engineering properties of Lateritic Blocks" He discovered that the compressive strength of the lateritic blocks produced from BLA blended cement revealed that

there is a strong relationship between compressive strength and the percentage of BLA cement, which implies that an increase in % replacements brings about a reduction in the strength. Olutoge [1] described the characteristic strength of groundnut shell ash (GSA) and ordinary portland cement (OPC) blended concrete in Nigeria with its pozzolanic activity. Raheem [7] conducted a study on saw dust ash as partial replacement for cement in concrete. In literature, the studies about the pozzolanic properties of bamboo trunk ash are scarce. Bamboo is one of the fastest growing and highest yielding natural resources and construction material available to mankind. In some advanced countries, significant amount of bamboo are processed, generating high volume of solid waste [5]. These wastes are often burnt in an open landfill, negatively impacting the environment.

This research is aimed to determine the compressive strength and pozzolanic capabilities of bamboo trunk ash as it partially replaces cement in varying percentage in mortar when silica sand is used as an aggregate

2. Methodology

The materials used for this research work were bamboo trunk ash (BTA), ordinary portland cement (OPC) conforming to ASTM type1, silica sand (fine aggregate) and water. The bamboo trunks were dried and later burnt in an open air for 3hrs to obtain the ash, which was later subjected to sieve analysis to determine the particle size distribution and the amount passing 75µm sieve for concrete mix. In order to reveal its chemical composition, the analysis of the BTA and OPC was done using Atomic Absorption Spectrometer (AAS) and the mortar production at various percentage replacements were conducted at the Chemistry and Concrete (Civil Engineering Dept.) laboratories

respectively, Federal University of Technology, Akure, Ondo State. The mix ratio used was 1:6 at different nominal replacement of OPC with BTA (0%, 5%, 10%, 15%, 20%, 25% & 30%) and water cement ratio of 1.6 by weight. Portland cement was partially replaced by Bamboo Trunk Ash (BTA) in a mix of 1:6 to determine the workability of the concrete mortars, and determination of compressive strength for 7, 14, 21 and 28 days curing days at different mix proportions.

Determination of Physical Properties of Silica Sand

- Natural moisture content in accordance to (BS 812-109, 1990)
- Particle size distribution (BS 812-100, 1990)
- Clay/Silt content analysis (BS 882, 1965)
- Specific gravity (ASTM D 854, 2014)

Tests on OPC and BTA

- Soundness test (BS 4550 – 3 (1978).
- Setting time (BS 4550 – 3 (1978),

Chemical Test on BTA and OPC – Atomic Absorption Spectrometer

Mortar Works – OPC/BTA and Silica sand

- Moulds- 50 x 50 x 50mm
- Batching and mix proportion, Mixing and mortaring operation- 1: 6 (Cement and sand)

Tests on Mortars

- Density test (BS 1015-11, 1999)
- Compressive strength (BS 5628-1, 1992)
- Water absorption capacity (BS 1015-11, 1999)
- Dynamic modulus of elasticity (BS 8110-1, 1985)

3. Results and Discussion

Physical Properties of Silica Sand

Table 1: Physical Properties of Silica sand

Properties	Values
Natural moisture content (%)	0.54
Highest grain size (µm)	212
Biggest grain size (µm)	600
Clay/ Silt (%)	5
Specific gravity	2.42

The summary results of the physical properties of silica sand before mixing with bamboo trunk ash are presented in table1. The natural moisture content of the silica sand was found to be 0.54% of the whole silica sand showing that the sand possessed low water retention capacity.

Table 2: Setting Time for OPC and BTA at varies Percentage

Setting time	OPC	BTA	BTA	BTA	BTA	BTA
	0%	5%	10%	15%	20%	25%
Initial (min)	52	56	62.24	88.6	109.5	110
Final time (min)	148	154	170	203	210	236

Table2 shows the result of initial and final setting time of Ordinary Portland Cement and Bamboo Trunk Ash (BTA) which indicate that initial setting time of 0% OPC is 52mins

of that of BTA 25% is 110mins while the final setting time of 0% is 148mins of that of BTA 25% is 236mins. The results indicate the initial and final setting time of BTA is more than OPC. The final setting time of OPC is 148 minute and BTA is 236mins. OPC and BTA satisfy the ranges of 45 – 600 minutes as stated in BS 4550 – 3, Section 3.6 (1978). The setting time is therefore tolerable.

Density Test

The average density at varying percentages of Bamboo ash replacement of cement was determined and shown in Fig.1. From Fig.1, the density when there was no bamboo ash in the mix was 2.04 g/cm³ and then decreased to 1.78 g/cm³ at 5% bamboo ash substitute for cement. The average density increased and decreased as the percentage of bamboo ash substitute for cement in the mix increases.

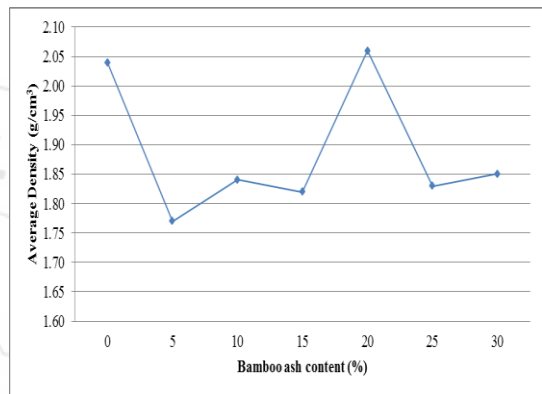


Figure 1: Average Density of Mortar cubes at varying Bamboo ash content

Water Absorption Capacity

Water absorption capacity at each bamboo ash replacement of cement was determined. This is shown in Fig.2. From fig.2, the control experiment (0% of bamboo trunk ash in the mix) the water absorption capacity decreased at day 14 of curing and increases to day 28 of curing. For 10%, 15%, 20% and 25% bamboo ash substitute for cement in the mix, the water absorption capacity increased to day 21 of curing and decreased at day 28 of curing. This is due to the fact that there were fewer voids in the cubes considered for the determination of the water absorption on the day of curing when it decreased.

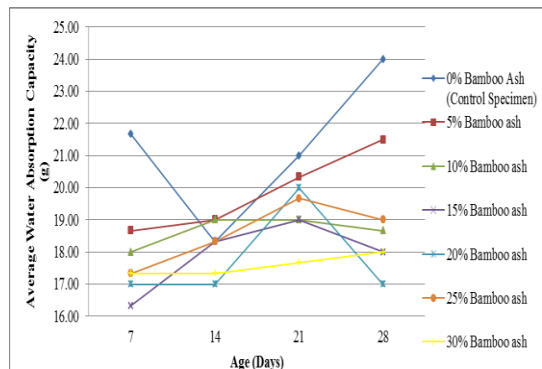


Figure 2: Average water absorption capacity of mortar cubes at varying bamboo ash content

Compressive Strength

The average compressive strength at varying percentages of Bamboo ash replacement of cement was obtained and then shown in Fig3. The 0% of Bamboo ash has its compressive strength to be increased progressively as the days of curing increased. For 5%, 10%, 15% and 25% Bamboo ash substitute for cement in the mix, the compressive strength decreased at the 14th day of curing and then increased till the 28th day of curing. The inconsistency in the compressive strength of the mortar as the age increased might be due to the fact that there was low rate of hydration at the day of curing when there was low compressive strength or there might be some ongoing chemical reactions that can affect the strength attainment or maturity of the mortar at these days.

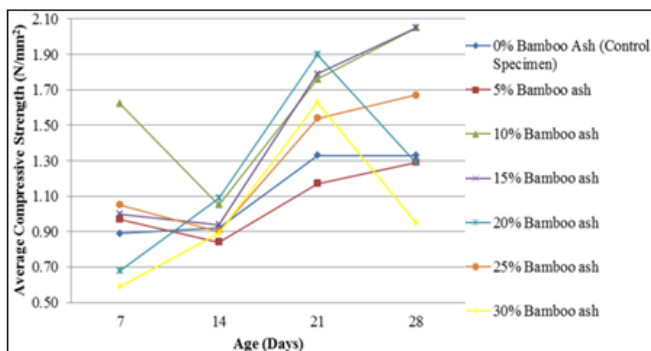


Figure 3: Average Compressive Strength against Age at varying Bamboo ash content

Dynamic Modulus of Elasticity

The average dynamic modulus of elasticity at varying percentages of Bamboo ash replacement for cement was obtained and then shown in Fig4. From Fig4, the results, just as in the case of the compressive strength, indicated that there were inconsistency in the dynamic modulus of elasticity of the mortar as the age of mortar increased and this might be due to the same fact that applied to that of the compressive strength of the mortar cubes.

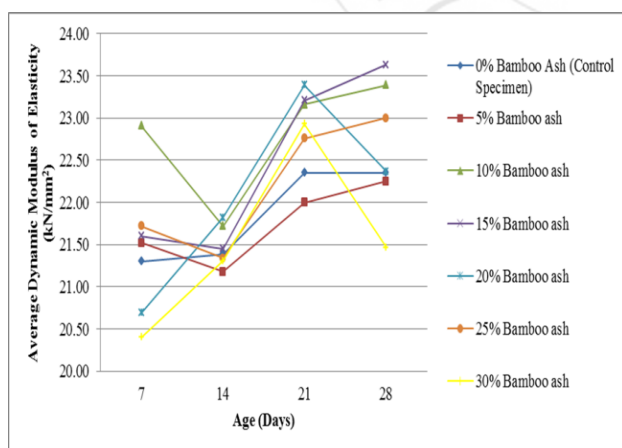


Figure 4: Average Dynamic Modulus of Elasticity against Age at varying Bamboo ash content

4. Conclusion

Partial replacement of cement with bamboo ash in the mortar significantly improved its water absorption and compressive strength. The suitability of silica sand as a fine

aggregate material in mortar making for bedding and jointing unit masonry and plastering works in building construction is relatively low. It is not the most suitable for use under the nature of work stated above because the strength obtained was 1.33 N/mm² (for the control experiment) at 28 days when six (6) portions of it were mixed with one (1) portion of ordinary Portland cement (OPC). This value is less than the standard requirement (3.6 N/mm²) provided in Table 1 of BS 5628 – 1 (1992). This is due to its weak rate of retaining water which leads to high water/cement ratio (1.4 as against 0.5 in the code) attained and eventually retards the strength maturity gained. It is also due to the variability in its particle size distribution compared to that of the standard sand used in mortar works.

5. Future Study

With high cost of building materials, Bamboo ash can be used in replacing part of the Ordinary Portland cement (OPC) to reduce cost especially in low – cost building schemes. Intense research work in the use of Bamboo ash should be carried out by varying the percentage of Bamboo ash to replace ordinary Portland cement (OPC), in order to know the effect of Bamboo ash on ordinary Portland cement (OPC) as its percentage changes. The use of silica sand obtained from elsewhere other than Igbokoda, Ondo State, Nigeria should be used for producing mortar under the same conditions of this project work to check its compressive strength in comparison with the one obtained in this research (control experiment) and the standard compressive strength specified in Table 1 of BS 5628 – 1 (1992).

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