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THE PRODUCTION OF A POZZOLANIC MATERIAL FROM THE LEAVES OF BAMBOO (*BAMBUSA VULGARIS*) IN NIGERIA

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ABSTRACT

A pozzolanic material is a siliceous or siliceous and aluminous material which, in itself, possesses little or no cementitious value but which will, in finely divided form and in the presence of water, react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties Bambusa vulgaris (bamboo tree) is a common plant found virtually in every parts o Nigeria. Some kilograms by weight of the Nigerian bamboo leaves were gathered, sun dried, incinerated and then heated in a closed furnace. The resultant powder was filtered and admixed with some Portland cement. The resultant samples of mortar were then compared with other samples of mortar not admixed with the pozzolanic material. The assessment showed that the mortar admixed with the locally produced pozzolanic material was better in molding into shape, permeability, workability, strength and showing less segregation than the other one not admixed with the produced material. The outcome of this work highlights the importance of pozzolanic materials in cement related construction and the relevance of the Nigerian bamboo leaves which are many times considered environmental problems.

Keywords: Pozzolanic Material, Babusa Vullgaris .

I. INTRODUCTION

A pozzolan is a siliceous or siliceous and aluminous material which, in itself, possesses little or no cementitious value but which will, in finely divided form and in the presence of water, react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties (Mehta 1987). The broad definition of a pozzolan imparts no bearing on the origin of the material, only on its capability of reacting with calcium hydroxide and water. A quantification of this capability is comprised in the term pozzolanic activity. (Snellings *et al.,* 2012) Pozzolanic materials not only strengthen and seal the concrete, but they have many other beneficial features when they are added to the mixture of cement and concrete.

A pozzolanic material has to contain reactive silicates or alumino-silicates. The particles must be fine enough to provide a sufficient reactive surface area for the solid-state chemical reactions. The particles react with the alkalis and calcium hydroxide from the cement to produce cementitious compounds (calcium-silicate hydrate gel, calcium-alumino silicates, etc.). Ordinarily, cement gives off lime as it hardens and this lime will inevitably react with silica (silicates or alumino-silicates). The aggregate in the concrete is basically silica, but unfortunately it reacts too slowly in the absence of a pozzolanic material. (Chappex and Scrivener, 2012)

There are many forms of pozzolans. These include fly ash (FA), rice husk ash (RHA) and silica fumes (SF). Recent study has shown that pozzolan can also be generated from bamboo leaves. There is a continuous search for alternative supplementary materials, which may have hydraulic/pozzolanic properties. This is much more important in developing countries, where there is shortage of power and good quality raw materials. (Dwivedia *et al.*, 2006)

Bamboo leaf is amorphous in nature and it is said to have pozzolanic properties. The annual production of bamboos all over the world is about 20 million tonnes but about 10 million tonnes are produced in India, China and Japan (Vatsala, 2003). This work is aimed at ascertaining the possibility of using the bamboo leaves which are common waste materials in Nigeria to produce pozzolanic materials.

II. MATERIALS AND METHODS

This work was carried out in the chemistry laboratory of Delta State Polytechnic Otefe-Oghara in Nigeria. Twenty Kilograms of dry bamboo leaves were collected from wild growing bamboo plants around the educational institution. The leaves were spread out over a dry concrete floor and sun-dried for seven days until they become husky and folded up. The sun-drying commences at 10am and stops at 4pm local time. This was to allow sufficient solar drying and prevents the morning and evening humid air from tampering with the drying process.

The next stage was to burn or incinerate the dried leaves in an open kiln. This was done in batches as the kin was not large enough to take all the raw materials at a go. The black bamboo ashes were then transferred to a furnace and heated for three hours at a temperature of 350^{O}C. The somewhat grey looking product was allow to cool and then filtered with a fine meshed net.

The next stage was to test the relevance of the product. This was done by admixing the pozzolanic material with different samples of mortar made from Portland cement and sharp sand. Other portions of pozzolan-free mortar were also made for comparison. Both sets of mortar were then tested along five parameters namely *shape, strength, permeability, workability and segregation.*

To test for the parameter of shape, and attempt was made to mold the two samples of mortar (one admixed with pozzolanic materials "WPM" and the other without pozzolanic material "WOPM") into different shapes. To test for strength, the different samples were subjected to battering using a small sledge hammer. The permeability test involved soaking the WPM and WOPM in a bowl of water for few minutes and then removing them to ascertain the level of permeability. In the workability test, attempts were made to ascertain the ease with which the two samples of mortar can be worked with. Using the hand trowel, the different samples were used to fill different holes in the wall.. This parameter tied closely with that of segregation. Here, the cementitious properties of the WPM and WOPM were ascertained by estimating what quantity segregated and fell off when in use.

III. RESULTS

The sun-dried bamboo leaves became slightly folded, turned husky and grey after the seven days solar drying. The ash was blackish after incinerating the leaves in the open kiln. However, the finished product has a somewhat grey colour after heating the black ash in the closed furnace.

When tested, there were sharp differences between the portions of mortar admixed with the locally produced pozzolan and those without the pozzolanic material. The details are shown in table 1 below.

Table 1. Comparison of different samples of mortar admixed with a locally made pozzolanic material with the one made from a plain Portland cement.

Parameters	Mortar with Pozzolan Material (WPM)	Mortar without Pozzolan Material (WOPM)
Shape	Mortar was found to blend freely with pozzolanic material, giving structures that were easily molded into different shapes.	Mortar was more coarse than otherwise. Moldings tend to disintegrate
Strength	This portion of the mortar seemed to be held together by some invisible threads. When hammered, the dry lump broke but not into pieces. Rather, it just gave way to the hammering but held together.	Subjected to the same force, the portion of WOPM showed a more disintegrating effect than the WPM
Permeability	When soaked in water and removed, there is this water proof-like property exhibited by the dry WPM sample. The water drained off and the solid sample got dried in no time.	The dry WOPM sample was heavier and more soaked with water than the WPM. It took a longer time for it to dry up when removed from the water.
Workability	The ease of working with the WPM sample was remarkable. It filled the hole and got stuck to the wall with ease. It also got dried up within a short time.	More effort was needed to work with the WOPM sample of mortar. One, the mortar hardly got stuck to the hole in the wall. Two, some particles of the samples were falling of as the hand trowel was used to push mortal in. Three, more effort has to be used in smoothing off the plasters than in the case of WPM sample.

Segregation	The wet particles of the WPM sample got stuck together when the mortar was being used. There was less disintegration.	The wet sample of WOPM showed some lever of charring and disintegration when being worked with.

In the course of assessing the WPM and WOPM samples, many other features were observed. Less volume of water is used in mixing the mortar of WPM than otherwise. It was also found out that less Portland cement was used for the same quantity of mortar in WPM samples than in the samples of WOPM. They all however point to the fact that mortar samples that were admixed with pozzolanic materials are better not only for construction but also in economic gains.

IV. DISCUSSION

The benefits of pozzolan utilization in cement and concrete are said to be threefold. First is the economic gain obtained by replacing a substantial part of the Portland cement by cheaper natural pozzolans or industrial by-products. Second is the lowering of the blended cement environmental cost associated with the greenhouse gases emitted during Portland cement production. A third advantage is the durability improvement of the end product. Additionally, the increased blending of pozzolans with Portland cement is of limited interference in the conventional production process and offers the opportunity to valorize large amounts of industrial and societal waste into durable construction materials. (Schneider *et al.*, 2011).

The importance of pozzolanic material in architectural structures is critical. The parameter of permeability and the conferment of water proof-like features on the structures is something that can solve the problems of weathering by water and rain. It said that the remains of the Minoan civilization on Crete have shown evidence of the combined use of slaked lime and additions of finely ground potsherds for water-proof renderings in baths, cisterns and aqueducts. (Spence and Cook, 1983). Evidence of the deliberate use of volcanic materials such as volcanic ashes or tuffs by the ancient Greeks dates back to at least 500-400 BC, as uncovered at the ancient city of Kameiros, Rhodes. (Idom, 1997).

The conferment of strength on Portland cement is also another critical relevance of pozzolanic materials cement related structures. The chemistry of the action is such that during hydration of Portland cement, $Ca(OH)_2$ is obtained as one of the hydration products, which in fact is responsible for deterioration of concrete. But when certain pozzolanic materials containing amorphous silica is added during hydration of Portland cement, it reacts with lime giving additional amount of calcium silicate hydrate (C-S-H), the main cementing component. Thus the pozzolanic material reduces the amount of $Ca(OH)_2$ and increases the amount of C-S-H. Thus if a good quality pozzolanic material in suitable amounts, is added during the hydration of Portland cement, the cementing quality is enhanced. (Chappex, T.; Scrivener K. (2012).

While trying to explore the benefits of pozzolanic materials in cement related structures, it is critical to note that this material can be produced from an almost insignificant raw material such as bamboo leaves. Natural pozzolans are abundant in certain locations of the world and are extensively used as an addition to Portland cement in countries such as Italy, Germany, Greece and China. The great majority of natural pozzolans in use today is of volcanic origin. Volcanic ashes and pumices largely composed of volcanic glass are commonly used, as are deposits in which the volcanic glass has been altered to zeolites by interaction with alkaline waters. (McCann, 1994) It is interesting to note that apart from rice husk, pozzolanic materials can be produced from bamboo leaves which are regarded as environmental problems in Nigeria. This work has shown that the bamboo leaves found in Nigeria can be used to produce pozzolanic materials. It has also shown vista of opportunity for the industrial production of pozzolans in Nigeria.

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