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CONCRETE MECHANICAL PROPERTIES OF USING CATTLE BONE ASH AS PARTIAL REPLACEMENT OF CEMENT

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Abstract

The study presents the behavior of concrete made with Cattle Bone Ash as a partial replacement of cement. Bulk density, sieve analysis, specific gravity of the ash and aggregate, consistency test, setting time and slump test of fresh paste were carried out to determine the suitability of the material for concrete making. Concrete mix ratio of 1:2:4 and CBA was used to replace cement at 0, 5, 10, 15 and 20% by weight. Samples of concrete cubes and beams were produced and cured for 3, 7, 14 and 28 days to determine their density, compressive and flexural strength. The result of the consistency test shows an insignificant change with varying quantities of CBA It was observed that the percentage decrease in compressive strength of concrete containing CBA [redacted] increased with quantity of CBA used from an average of 12.04% at 5% replacement level to 52.63% at 20% replacement level. The flexural strength on the other hand showed a rise in strength after 28 day curing period of about 5%.

KEYWORDS: *Cattle bone ash, Composition, Concrete, Replacement and Strength.*

Introduction

Concrete, a primary building construction material partly due to the fact that is produced from natural materials available in all parts of the globe and partly due to the fact that it is a versatile material giving architectural freedom (Glavind, 2006) is the worlds most consumed man-made material

(Soroushian, 2012). While Cement is recognized as a major concrete binder throughout the world, researchers today are focusing on ways of utilizing either industrial or agricultural waste, as a source of raw materials for the construction industries. And surprisingly, concrete with cement replacement materials can actually be stronger and more durable than concrete with Ordinary Portland Cement (OPC) and contributes towards the development of green concrete based infrastructure. In recent years, attention has been drawn to the utilization of agricultural residue such as rice husk, sugarcane bagasse, bamboo leaves and acha husk all in ashes. Also in focus is the utilization of residues from the combustion of pulverized coal, fly ash and many of such (Joel, 2010). The interest of the construction community in using waste or recycled materials in concrete is increasing because of the emphasis placed on sustainable construction (Vijaykumar G., 2013) and because of the various disadvantages of the popular cements, gravels etc. disadvantages like the huge foreign exchange expenditure due to the importation of input materials, the cost of cement most especially is exceedingly high to the extent that it would be better to build with minimum cement content (Utsev & Taku, 2012).

Cement is not an environmental friendly material as the pollution associated with its production is at 0.815 to 1.0 tones for each ton of cement produced (Yeung, 2003) (Islam, 2010), while the manufacturing of the cement is also an energy intensive process. Continues generation wastes arising from industrial by-products and agricultural residue such as rice husk, groundnut husk, corn cob and coconut shell, Quarry Dust, Saw Dust etc create acute environmental problems both in terms of their treatment and disposal (Raheem, 2012), hence the need to convert them into useful materials to minimize their negative effect on the environment (Kumar, 2014). It was reported (Job, 1998) that efforts have been made to partially substitute cement with locally available materials called pozzolanas. Pozzolan is a siliceous material that can be used as an inexpensive substitute for cement in mortar mixtures as explained by (Ghassan, 2011). The American Society of Testing Materials (ASTM, 1988) defines Pozzolans as a siliceous or aluminous materials which possess little or no cementations properties but will, in the presence of moisture, react with lime [$Ca(OH)2$] at ordinary temperature to form a compound with pozzolanic properties (Utsev & Taku, 2012) These substitute materials may be used solely or in partial replacement with the popular materials. Waste, utilization would not only be economical, but may also result in foreign exchange earnings and environmental pollution control

(Srinivasan, 2010), The use of solid waste materials or industrial by-products as partial replacement for cement in concrete is a viable strategy for reducing the use of Portland cement, and thus reducing the environmental and energy impacts of concrete production (Soroushian, 2012).

The quest for the local materials to serve the building and construction industry in Nigeria has been on-going for quite a while (Ajileye, 2012). It was explained by (Olawuyi, 2012) that in spite of the large number of cement factories in the country, the yearly supply does not match the demand. To worsen the situation most of these factories do not produce at full installed capacity and because the importation of cement is economically inadvisable, the difference between demand and supply invariably has an effect on the cost of cement. The need to explore means to reduce the use of expensive cement as much as possible brought the idea of using Cattle Bone (CB) was encourage as explained by Aribisala and Bamisaye, 2006. Falade et el 2012 confirmed that cattle born could be used to partially replace cement in concrete. This animal waste after slaughter has been unutilized for a very long time in this country in fact quite some percentage has been explored. The Cattle bone is mostly found at abattoirs and butchering centers nationwide. The use of CB as partial replacement will indeed be another discovery in the construction industry. Currently, little or no use of this waste is being made in the construction industry. And, because current use for it is limited, they represent a potential source of inexpensive construction material. It is feasible that a significant portion of cement in a concrete mixture may be replaced by Cattle Bone Ash (CBA). According to (Joel, 2010), at 10% replacement there is a 7.14% increment in compressive strength of the concrete while all other agro waste in his study did not exhibit a convincing increment in strength. Falade et al 2013, in their work explained that pulverised bone can be used in the production of aerated concrete. They went further to conclude that the cost reduction of over 30% is viable if CBA is used as cement replacement. This study explores the properties of concrete mixes after the addition of CBA. The aim of this study is to further determine the suitability of CBA for use in concrete production. The objectives include ascertaining the optimum replacement level of OPC with CBA that will still give required compressive strength as well as compare the setting times of OPC paste with OPC- CBA pastes at various replacement levels, the large calcium content of the waste is an alternation that should not be overlooked.

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MATERIALS AND METHODS

The raw material CB was obtained from the Muda Lawan Market of Bauchi. The CB is air dried and then a hard brush was used to remove animal remains and dirt from its surface. It was then burned in a close incubator for 75 minutes under temperatures ranging between 650 – 700C° and then allowed to cool. The hard bone was then grinded to powder and passed through a 2μm sieve.

The ratio of concrete mix used was 1:2:4 by weight (cement, sand and water) while the water/cement ratio of 0.5 was adopted. 150 mm Concrete cubes and beams of (300x100x100) were casted to determine the compressive and flexural strength of the concrete respectively at each of the replacement levels.

For easy identification the sample of the replacement levels of 0%, 5%, 10%, 15% and 20% where presented as CBA0, CBA5, CBA10, CBA15 and CBA20 respectively.

Table 1: Quantities of each replacement level

Batch	Cement (kg)	CBA (kg)	Sand (kg)	Gravel (kg)	Water (kg)
CBA0	17.64	0	29.5	60.75	8.8
CBA5	16.76	0.88	29.5	60.75	8.8
CBA10	15.88	1.76	29.5	60.75	8.8
CBA15	14.99	2.65	29.5	60.75	8.8
CBA20	14.11	3.53	29.5	60.75	8.8

Table 2: Physical Properties of CBA

Elements	CBA
Apparent specific gravity	2.43
Loose bulk density (kg/m^3)	1325
Compacted bulk density (kg/m^3)	1580

RESULTS AND DISCUSSION

The specific gravity of CBA (2.43) which is the ratio of the weight of a given volume of the CBA to the weight of a given volume of water discharge is lower than that of OPC (3.15) which means that for the same mass of the two substances the volume of the CBA will be higher, this also explains that the density of paste with lower mass or no OPC will be lower than that with higher mass of OPC and lower density of paste is an indication of higher porosity within the internal matrix of the paste with high CBA (Falade et el, 2012)

Table 3: Workability of paste samples

Mix proportion	Slump	Free fall (kg)	Compacted (kg)	Compacting factor
CBA0	40mm	10.8	12.0	0.90
CBA5	40mm	10.9	12.0	0.91
CBA10	40mm	10.9	12.0	0.91
CBA15	40mm	10.9	12.0	0.91
CBA20	40mm	10.9	12.0	0.91

From table 3 it is notice that the control (CBA0) and the replacements are having the same slump; this maybe because the CBA did not absorb much water contrary to what was expected, the replacement when added did not alter the weight of the concrete which can be attributed to the result of the compacting factor test, which show relative or no change in the compaction factor. The values of the slump show that the lubricating nature on the concrete is not affected by the addition of the CBA (Neville & Brooks 1990).
The initial and final setting time of the cement without replacement was slightly delayed but remain within BS12(1978) limit. The delay is likely due to the exposure of the cement before use and the high water cement ratio of 0.5 used. From table 4 it is observed that an increase in percentage of CBA to cement increase the initial and final setting time, this can be attributed to the high calcium oxide content in the CBA.

Table 4: Final and Initial Setting Time

Mix proportion of cement and % of CBA	CBA0	CBA5	CBA10	CBA15	CBA20
Initial setting time (minutes)	190	200	237	285	316
Final setting time (minutes)	270	280	317	365	396
Difference (minutes)	80	80	80	80	80

The compressive strength of each series at each curing day as presented in fig. 1 shows increase in strength with respect to the curing days at all the replacement levels. However, the compressive strength of the control is higher in all test samples with only a higher level recorded at 10% at 7 day curing. The reduction in strength can be attributed to the addition of CBA. From the table it can be seen that the percentage decrease in compressive strength increases with higher replacement levels with an over 50% decrease in strength at 20% replacement level in all the ages of the concrete as represented in fig 2. The flexural strength on the other hand showed an appreciating raise in strength after 28 days of curing and in this case the strength gained at 20% replacement level at 28 days curing period was higher than the control as presented in fig. 3, this could be attributed to the high CaO component in the CBA.

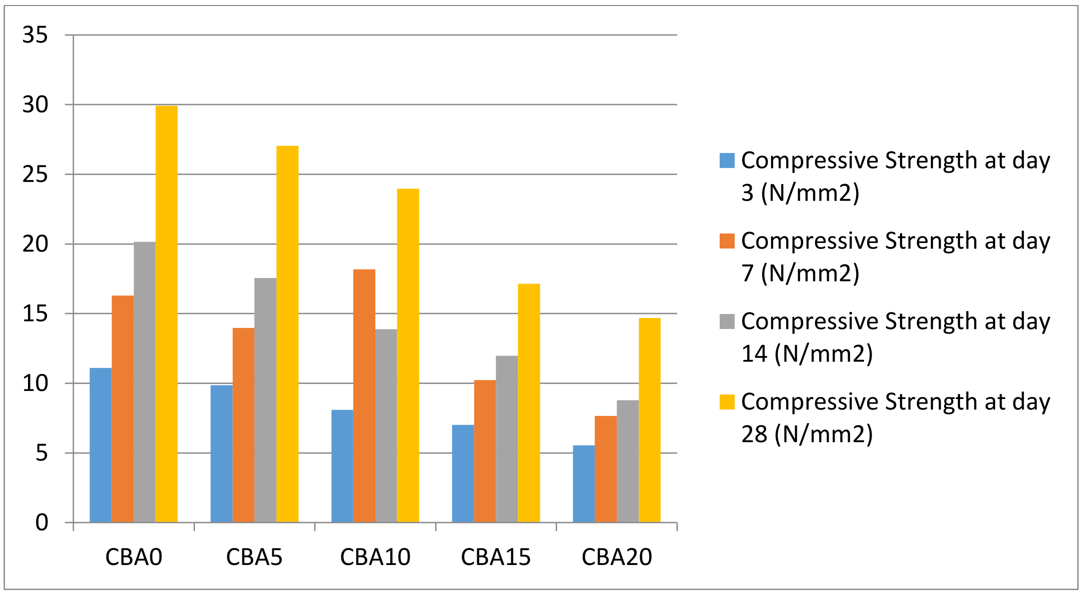

Fig. 1: Compressive strength of concrete at various replacement levels of CBA

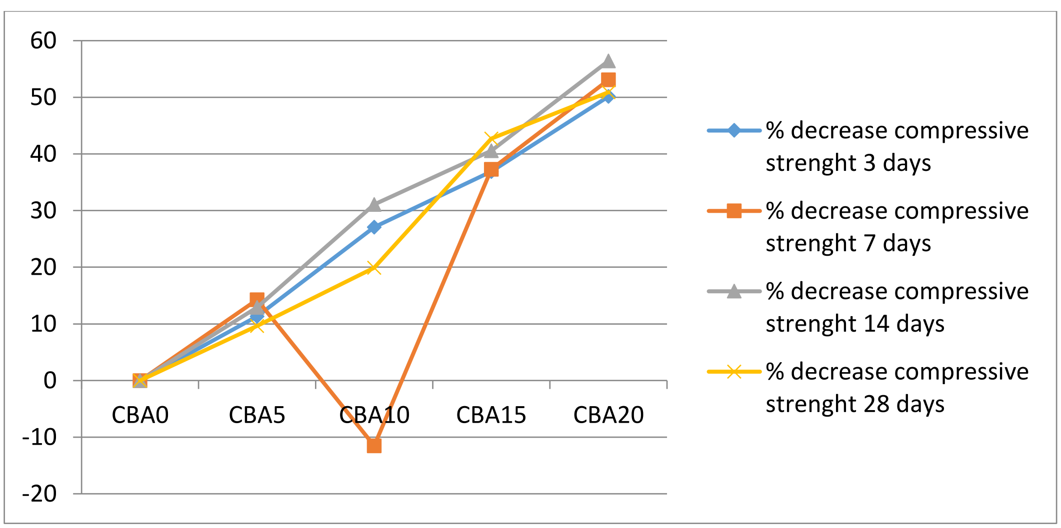

Fig. 2: Percentage decrease in strength against replacement level

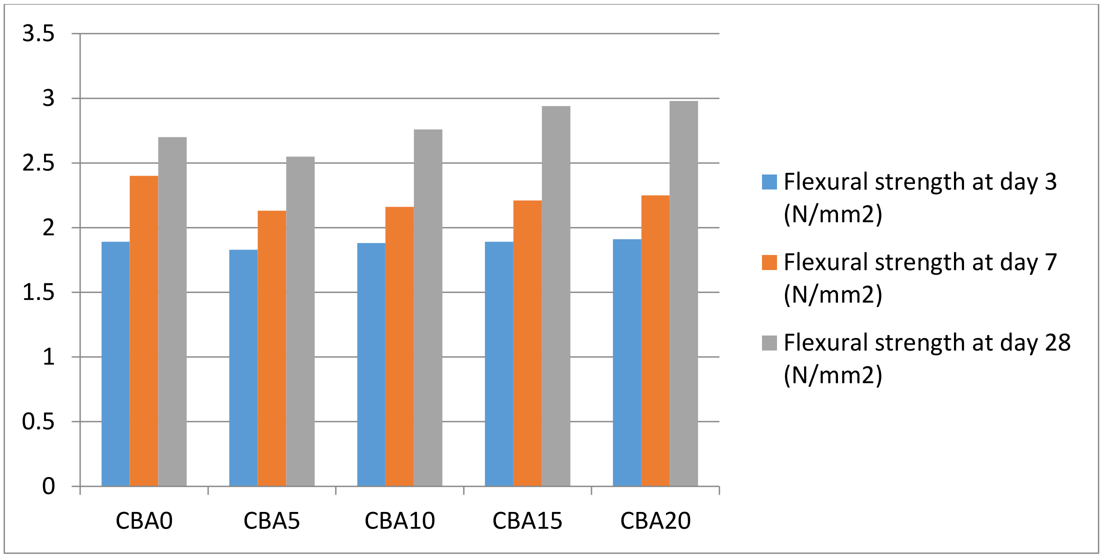

Fig. 3: Flexural strength of concrete at various replacement levels of CBA

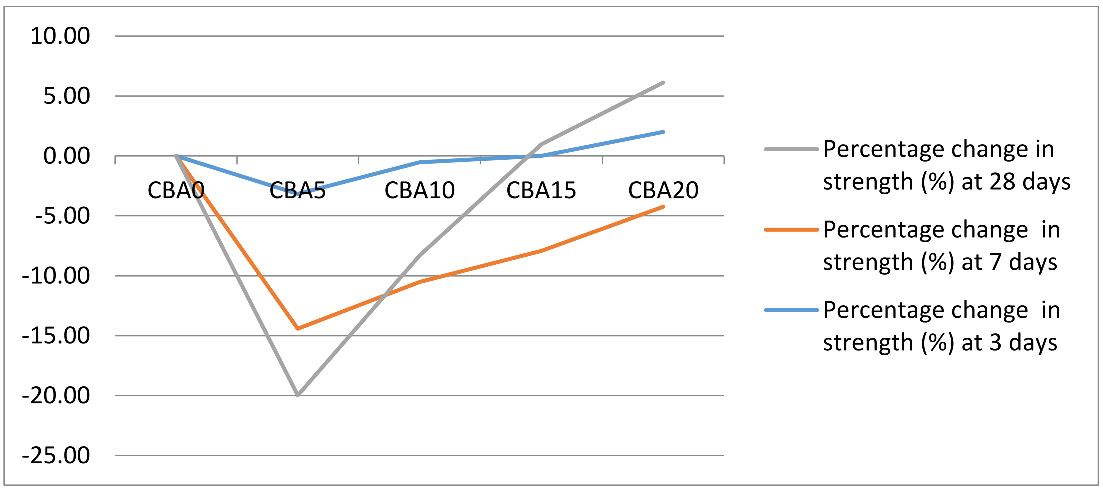

Fig. 4: Percentage change in flexural strength against replacement level

CONCLUSION

From the preliminary study of the technical feasibility of using CBA as a partial replacement of cement in concrete production, the following conclusion can be drawn

a. There is an increase in both initial and final setting time upon the addition of CBA but the setting times are within the limit recommended by BS 12 (1978).
b. There is no degeneration observed since strength continued to increase as the hydration progresses. All concrete observed shown appraisable strength at 28 days.

c. Based on the Specific Gravity test of the experiment the specific gravity of the CBA is almost the same with that of cement. There was also no appreciable loss of weight from the weight of the cubes.
d. The compressive strength of the CBA when replaced with cement cubes has a decreasing compressive strength at all the hydration periods. The increase of calcium oxide by addition of CBA resulted in the high calcium oxide in the concrete, would be the likely effect on the delay in strength achieved.
e. There is an appreciation in flexural strength at all the replacement levels after 28 days of curing.
f. The increase in flexural strength with increase in hydration period and replacement level could be attributed to the fact that CBA does not act as a retarder.

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