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COMPRESSIVE STRENGTH OF COCOA POD ASH BLENDED SANDCRETE BLOCKS PRODUCED IN OSOGBO, NIGERIA

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Abstract: The problem of non-uniformity in the sandcrete blocks production process practiced across the broad spectrum by manufacturers and the desire to improve profit in the face of dwindling resources and inflationary pressure of price of raw materials leads to the production of sandcrete blocks of low quality. This work investigates the use of Cocoa Pod Husk Ash (CPHA) as an additive in sandcrete block production. The effect of CPHA addition on compressive strength of locally produced sandcrete blocks from three different sources within Osogbo was investigated at 1, 2, 3, 4 and 5% CPHA replacement by weight of cement. It was revealed that the compressive strength of blocks produced increased by more than 400%. This is encouraging and further work on developing the practice business model is being undertaken to completely convince the local manufacturers of the importance of using this additive to produce better sandcrete blocks, than presently available in the market.
Keywords: cocoa pod husk ash, sandcrete block, compressive strength

1. INTRODUCTION

The production of local sandcrete blocks is never a regulated industry and there has been serious abuse of practice as reported by Anosike and Oyebade (2012). This has been one of the suspected causes of incessant building collapse being experienced in the country. Although there is no statistical data to indicate the spatial distribution of building collapse across the country; however, it does not take a genius to suspect the poor quality of locally produced sandcrete blocks. A mere visit to the production sites of these locally produced sandcrete blocks will reveal the inherent problem of profit maximization at the expense of quality and safety whereby, almost mud material is used in place of river washed sand. Also, the number of blocks output per bag of cement is always optimized leading to poor and weak blocks being produced. Most of these blocks collapsed under the stacking weight alone talk less of being used to construct load-bearing walls in a building. It is impossible to stop the practice in a country where corruption permeates the system from top to bottom. The only solution left is to find a means of improving the strength of the products without altering the materials and cost of production. The question arose on finding a solution to improving the strength of these blocks at minimum or no cost with a significant improvement in the strength of the blocks.

The search for solution to the above stated problem lead to this study employing the use of CPHA as a strengthening medium. The abundance of CHPA is an attraction for its choice in this study. The ash is produced at little or no cost to the local producers of these blocks. Generally, the high cost of cement used as binder, in the production of mortar, sandcrete blocks and concrete has led to a search for alternatives, in addition to cost, high energy demand and emission of CO_2, which is responsible for global warming, the depletion of lime stone deposits is a disadvantage associated with cement production. According to Oluremi (1990), about 7% CO_2 is released into the atmosphere during cement production, which has a negative influence on ecology and future of human health arising from global warming. In developed countries, according to Michael (1994), the most common and readily available material that can be used to partially replace cement in sandcrete blocks production without economic implications are agro based wastes, notable ones are Acha husk ash (AHA), Bambara Groundnut Shell Ash (BGSA), Bone Powder Ash (BPA), Groundnut Shell Ash (GSA), Rice Husk Ash (RHA) and Wood Ash (WA). Additional agro waste materials include ashes from the burning of dried banana leaves, bagasse, bamboo leaves, some timber species, sawdust and Periwinkle Shell Ash (PSA).

Apart from obvious advantages of low cost of production resulting from the reduced quantity of cement, promotion of waste to wealth agenda leading to a reduced pollution from these wastes and subsequent reduction in the CO_2 emission from the reduction of cement input in the production of these blocks. According to a study conducted by Anosike and Oyebade (2012), the common mixing ratios employed by sandcrete block manufacturers around Osogbo and environ are;

- 1:5 – This implies 1 bag of cement and 5 wheel barrows of sand.
- 1:6 – This implies 1 bag of cement and 6 wheel barrows of sand.
- 1:8 – This implies 1 bag of cement and 8 wheel barrows of sand.

According to NIS 587 (2007) as shown in Table 1, various sizes of blocks determine their usage not considering the compressive strength of the blocks produced.

Hollow sandcrete blocks containing a mixture of sand, cement and water are used extensively in many countries of the world especially in Africa according to Oyekan and Kamiyo (2011). In many parts of Nigeria, sandcrete block is the major cost component of the most common buildings. The high and increasing cost of constituent materials of sandcrete blocks has contributed to the non-realization of adequate housing for both urban and rural dwellers. The production of cement contributes significantly to the emission of carbon dioxide, a naturally occurring greenhouse gas.

Table 1: Types of Sandcrete blocks and their uses

Type	Work size L x H x T (mm)	Web thickness (mm)	Usage
Solid Blocks	450 x 225 x 100	-	Non load-bearing walls
Hollow	450 x 225 x 113	25	Non-load-bearing walls
Hollow	450 x 225 x 150	37.50	Non-Load-bearing walls
Hollow	450 x 225 x 225	50	Load-bearing walls

The sandcrete block industry is constantly looking for supplementary cementitious material with the objective of reducing the solid waste disposal problem generated due to agro waste production. For instance, quarry dust (QD) is the by-product obtained during the crushing and washing of stones from the crushing units. Wood ash is a by –product of wood in boilers at paper mills and other burning facilities. Khaza and Vasugi (2014) reported that substantial energy and cost savings can result when industrial by-products are used as partial replacements for the energy-intensive Portland cement, thus generating an increase in demand for the materials which can be alternated for cement and sand in sandcrete.

Agro waste materials such as, rice husk ash, palm kernel ash and groundnut shell ash have been successfully used as additives in sandcrete block production for decades. The successful usage as an additive, contributes to the resolution of the landfill problem and reduction in the cost of building materials, provides a satisfactory solution to the environmental issues and problems associated with waste management, saves energy, and helps to protect the environment from pollution. Agricultural wastes, such as rice husk ash, wheat straw ash, and sugarcane bagasse ash, hazel nutshell ash which constitute pozzolanic materials can be used as additives in sandcrete blocks production according to Khaza and Vasugi (2014). Bakar *et al.* (2010) assert that supplementary cementitious materials prove to be effective to meet most of the requirements of durable concrete and that blended cements are now used in many parts of the world.

CPHA has been used in various forms to achieve better crop yield in non-fertile farm lands. Ayeni (2010) established the versatility of CPHA as poor soil nutrient booster. CPHA has been effectively used to improve the valuable nutrients of clayey soil leading high yield of maize in some localities in Nigeria. In another development, Amoanyi *et al.* (2012) reported of an improved wet and dry compressive strength of Afari and Mfensi clay in Atwima Nwabiagya District in Ashanti Region of Ghana. The addition of 10 and 15% of lime and CPHA resulted to significant increase in the wet and dry compressive strengths of this clay. In another development, it has been established that CPHA is a good strength booster in earth bricks. This is could be a solution to the problem of shortage of housing in Africa. As reported by Manu *et al.* (2015) CPHA was effectively used as a stabilizer in the production of stabilized earth brick leading to its improved engineering characteristics. However, Anthony *et al.* (2014) concluded to the contrary that CPHA additive is detrimental to the engineering and geotechnical properties of lateritic soil for road construction work. They concluded that CPHA has no pozzolanic properties. This paradoxical experiences has made imperative to investigate further how best to use CPHA in other materials such as sandcrete blocks.

2. RESEARCH METHODOLOGY

This work attempts to recreate the production paths followed by the local sandcrete block producers to have a common denominator for the comparison and more importantly to prevent any deviation from their practice so as to be able to see the improvement of the CPHA additive on their locally produced blocks. Cocoa pod husks were obtained from farms in Osogbo, Osun State. The husks were spread out on clean surfaces and air dried to facilitate burning. The pods were then burnt in drums into ashes. After cooling, the ashes were sieved through British Standard sieve 212µm for block production. According to Amoanyi (2012), CPHA consists of 8.05% SiO_2, 2.28% Al_2O_3, 0.89% Fe_2O_3, 8.43% CaO, 5.16% MgO, 37.39% K_2O, 2.09% SO_3 and 32% LOI. This showed that the total composition of SiO_2, Al_2O_3 and Fe_2O_3 is far less than minimum requirement for any classes of pozzolans according to ASTM C618.

Cue was taken from three local manufacturers of sandcrete blocks who are the major suppliers of blocks around the Osun State University area where there has been a significant increase in building construction to cater for the growing demand of accommodation. Their production methodologies were assessed in order to produce the blocks used in the present study. Also, samples were collected from these three producers used as control samples. The study could not ascertain the ages of these samples but it was assumed that the production mechanics would not deviate spuriously from the norm. The source of the river washed sand used by the local manufacturers was identified and other materials employed by this study, were collected from the same source. Sieve analysis of sands from the three producers used in the present work were carried out and compared as shown in figure 1, the results show that the samples satisfy the overall grading limit as specified by BS 882 (1992). The same batching system of the use of wheel barrows for the sand measurement was used for this study. The batch ratio of 1 bag of cement to 6 wheel barrows of sand was scaled down in order to produce the blocks on a small scale and the CPHA additive was made from raw cocoa pod.

The additive of 1, 2, 3, 4 and 5% by weight of cement replacement was used in the present work. The blocks were produced by hand compaction which mimics the local producers' method. The blocks were tested at 7, 14 and 28 day curing periods; then basic compressive strength test using the standard compression machine was carried out. The failure load of each test specimen was recorded and the load bearing surface area was used to compute the compressive strength of the tested blocks. The samples from the three control producers were tested similarly.

3. RESULTS AND DISCUSSION

Figure 1 shows the comparison of sieve analysis of the fine aggregates obtained from the three factories and the one used in this study. It was observed that the sieve curve of the current study material is very representative of the materials obtained from the other sites. This curves envelopes the other three curves and it follows the same trend like the other sites. It establishes the fact that the same material as those of local producers is used in this study. This is important in order to replicate their production condition. The cement is from the same source and brand (Dangote cement). The only material different is the source of water that was collected from the local stream flowing through the campus. The replication of near the same conditions put this study on the common denominator as the local producers.

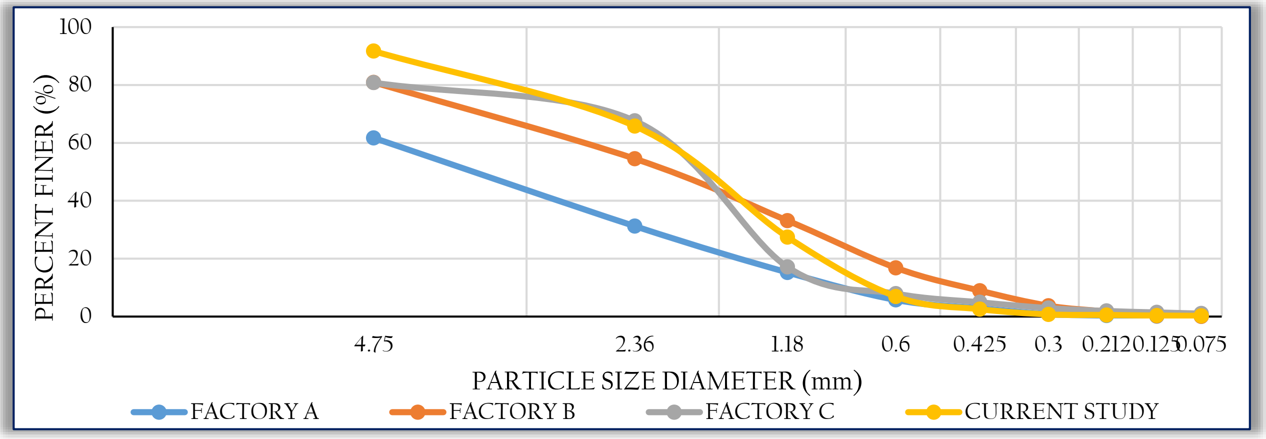

Figure 1: Comparison of Sieve Analysis results of the sand material

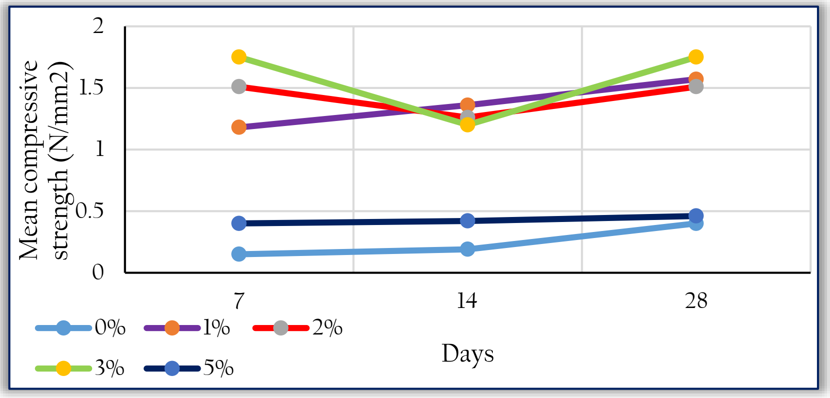

Figure 2: Line graph of Mean compressive strength versus curing days for all percentage additions.

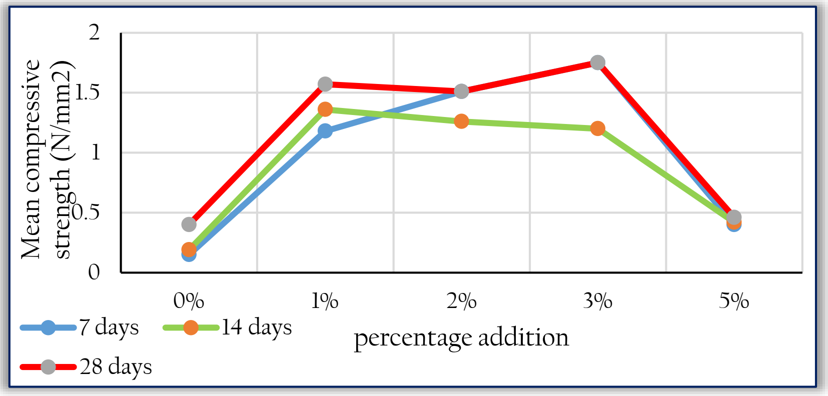

Figure 3: Line graph of Mean compressive strength versus percentage addition at 7, 14 and 28 days respectively.

The results presented in Figures 2 and 3 clearly demonstrate the huge improvement in compressive strength with CPHA over the local blocks without the additive. The graph of the average compressive strength with curing ages of 7, 14 and

28 days for various CHPA contents are shown in Figure 2. It is interesting to note that for 2 and 3% CHPA additive, the strength dips at 7 day curing age. This indicates that optimum strength is guaranteed from 28 days and above. The most beneficial regime of additive content is around 3% as shown in both Figures 2 and 3. This regime consistently shows steady increase in the strength over the curing ages considered in this study. The percentage increase in strength at this additive regime is more than 400%. The average compressive strength of the control samples is about 0.4 MPa. This is consistent with the findings of Oyekan and Kamiyo (2011).

4. CONCLUSION

It is interesting to note the huge improvement in compressive strength of locally produced sandcrete blocks by adding CPHA to the local process. It can be observed that the optimum percentage of CPHA is 3% that resulted to about 500% increase in compressive strength. It is also observed that any proportion of CPHA addition up to 5% is of great benefit. This wide range of volume addition of CPHA is a safety net because there is propensity for the abuse of this material by the local producer of sandcrete blocks. This will reduce the risk of over usage of the additive. The underlining problem of weak and inconsistent products being used in the building industry in the study localities of Osogbo cannot be overemphasized. Hopefully, the use of CPHA will reduce the problem of weak sandcrete block production in the locality of study. The rate of building collapse around these localities is high. Hopefully, the use of this additive at very low extra cost and even reduction of cement consumption will reduce the rate of building collapse under construction due to use of weak locally produced blocks.

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