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THE USE OF CEMENT KILN DUST AS PARTIAL REPLACEMENT TO ORDINARY PORTLAND CEMENT IN HOLLOW LATERITIC BLOCKS

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ABSTRACT

The effect of partial replacement of cement with cement kiln dust (CKD) on the compressive strength of laterized hollow block was investigated. A total of 270 number of 450mm x 225 mm x 150mm hollow blocks using different mix were moulded and tested at 7, 14 28 days with replacement by CKD ranging from 10-50%. The results show that the compressive strength decreased with increase in CKD content. The 28 day compressive strength for 10% CKD replacement for 1:8 and 1:10 mixes were observed to exceed the minimum strength of 1.75N/mm^2 required by the Nigerian National Building Code for individual block. The strength of the laterized blocks however increases as the curing age's progresses.

Keywords: cement kiln dust, sandcrete blocks, compressive strength, curing.

1. INTRODUCTION

The over dependence on imported and manufactured building materials such as cement, lime etc, by developing economies is one of the factors militating against sustainable projects and, hence, sustainable infrastructure development in these countries. As highlighted by Kerali (2001), the majority of developing countries are today faced with an ever increasing problem of providing adequate yet affordable housing in sufficient numbers. In the last few decades, shelter conditions have been worsening: resources have remained scarce, housing demand has risen and the urgency to provide immediate practical solutions has become more acute.

The Niger Delta area of Nigeria appears to favour the use of sandcrete block as the most commonly utilized walling unit. Perhaps, due to the heavy rains experienced in this part of the country, earth block technology is not popular among the Niger Deltas. This has placed a high demand on sandcrete blocks for housing.

The commonest walling unit used in construction of buildings in Nigeria is the sandcrete blocks. According to Barry (1969), sandcrete blocks are composite material made up of cement, sand and water, moulded into different sizes. They are widely used as walling unit in Nigeria and other countries like Ghana, Irish etc, (Abdullahi, 2005).

The most important constituent of sandcrete is cement; incidentally, this is also the most expensive component. To cut down cost and maximize profit, producers of these blocks in Nigeria reduce the quantity of cement needed to give acceptable quality of sandcrete blocks, leading to the flooding of low- strength blocks in the commercial market. Industrial and agricultural wastes, such as cement kiln dusk (CKD) have posed environmental problem at cement factories. It utilization in hollow sandcrete blocks will make for sustainable construction. The introduction of cement kiln dust can be viewed as effort to convert a material considered to be waste for use in construction and blocks making. The cost of river sand as a constituent in the production of sandcrete blocks is also partly responsible for the relatively high cost of the blocks. Meanwhile, lateritic soils are abundantly available in Nigeria and their potentials as building materials have not been strategically optimized by the drivers and enablers in the Nigerian construction industry.

2. PREVIOUS STUDIES

Bhatty (1996) observed that cement kiln dust has application in soil stabilization and as a filler material in civil engineering works. Okafor and Ewa (2012), Cement kiln dust has proved to be a good soil stabilizer for expansive clay. Zaman (1992) concluded that cement kiln dust recorded similar results in soil stabilization as does, cement, fly ash and lime.

The properties of hollow sandcrete blocks with cement kiln dust as a Portland cement replacement material and as an additive were investigated by Udoeyo and Ridnap (2002), it was reported that when cement kiln dust was used as a cement replacement material, the compressive strength and the density of the blocks generally decreased with higher replacement levels of ordinary Portland cement by cement kiln dust, while the percentage water absorption of the blocks increased with higher replacement levels. On the other hand, when cement kiln dust was used as an additive, within the investigated levels, an improvement in the compressive strength of up to 54% was observed. The density of the blocks also increased with higher cement kiln dust content. Ravindrarajah (1982) cited in IEEI-IAS (2008) reported that kiln dust could be used in masonry and concrete block without loss of strength or workability. His study showed that up to 15% of Portland cement could be replaced with cement kiln dust and if higher percentages of the dust were used, the setting time was retarded, workability reduced and water demand was increased. Also El-Inein (1994) observed that in blended cement, the compressive strength decreased when more than 15% of the Portland cement was replaced with cement kiln dust.

3. OBJECTIVES OF STUDY

This research work aims at investigating the effect of cement kiln dust on the compressive strength of cement stabilized lateritic block. The objectives of this research include:

a) To determine the effect of partially replacing ordinary Portland cement with cement factory wastes (cement kiln dust) on the compressive strength of stabilized lateritic blocks.
b) To determine the optimum replacement of cement with the cement kiln dust.
c) To determine whether or not the stabilized lateritic blocks can be used for load bearing walls.

4. MATERIALS AND METHODS

The Laterite used for this research work were obtained from borrow pit in Calabar Municipality (Lemna borrow pit). The cement used was ordinary Portland cement manufactured by United Cement Company of Nigeria (UNICEM). The cement kiln dust was obtained from UNICEM factory. All these material were gotten from Calabar, Cross River State, Nigeria. Calabar is located 55km upstream of the Calabar River, at Longitude $8^0 17^1$E and Latitude $4^0 81^0$ N. The laterite collected was air dried in the open floor of the workshop and screen through a 212µmm sieve before it was used for block moulding. The Portland cement was obtained in 50Kg bags and stored in the workshop on timber planks, away from moisture prone areas. During the block moulding process, the opened bag was sealed after each sample collection to avoid the ingress of air and moisture. The cement kiln dust (CKD) was stored in air tight bags and preserved in the same way with the cement, to avoid exposure to air and moisture. The index properties of the laterite showed that the soil had a plasticity index of 9.0% and is classified as SiltyClay of low plasticity from the Casagrande Classification Chart. Figure-1 shows that the laterite soil is well graded. The specific gravity was 2.60 with a maximum dry density of 1.90kg/m^3 at an optimum moisture content of 9.60%. The characteristics of the cement kiln dust used are presented in Table-1. The cement used had a specific gravity of 3.15. The water for moulding was portable drinking water from Cross River University of Technology, Calabar water mains supplied to the Laboratories.

Hollow stabilized blocks of 450mm x 225 mm x 150mm with cement to soil ratios of 1:8, 1:10, 1:12, 1:14 and 1:16 were moulded. For each test level, nine (9) blocks were moulded and cured for 7, 14 and 28 days. This same test was repeated at 10%, 20%, 30%, 40% and 50% cement replacement with CKD. Weight batching was adopted and each water/cement ratio determined for each mix.

Table-1. Composition of cement kiln dust (CKD) used.

Constituent	SiO_2	Al_2O	CaO	MgO	SO_3	K_2O	Na_2O	Cl	LOI	Free CaO
% Composition	14.79	4.51	57.39	2.66	10.48	1.26	0.18	0.31	4.38	4.04

5. RESULTS AND DISCUSSIONS

5.1. Chemical properties of cement used

Table-1 shows that the properties of cement used for moulding the blocks meet the specification for Ordinary Portland Cement, Neville (2000). The specific gravity of the cement used was 3.51.

Table-2. Chemical properties of cement used.

Constituent	Cao	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	K_2O	NaO_2
Percentage	64.34	20.79	4.51	2.64	1.66	1.48	1.26	0.18

Table-3. Particle size distribution of laterite.

Sieve sizes	2.36	1.18	0.6	0.425	0.3	0.212	0.15	0.063
% Passing	91.5	69.5	30.6	18.8	9.8	7.4	6.15	5.3

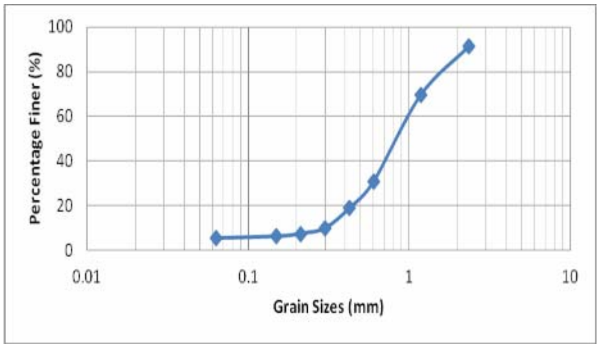

Figure-1. Particle size distribution curve for laterite.

5.2. Compressive strengths of stabilized lateritic blocks

The results of the compressive strengths of cement stabilized lateritic blocks are presented in Figure-2. The 28 day strengths of blocks made from 1:8, 1:10 and 1:12 mix ratios range from 1.80 N/mm^2 to 3.01 N/mm^2 and meet the minimum requirement of 1.75N/mm^2 by the Nigerian National Building Code for individual block. The strength of 3.01 N/mm^2 of 1:8 mix satisfied the requirement of the Nigerian industrial standard. The 28 day strengths of 1:14 and 1:16 did not meet the minimum standards.

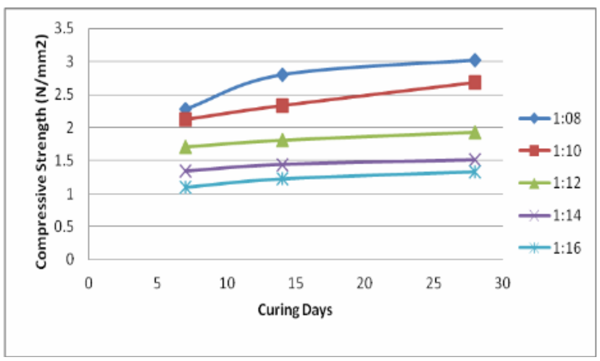

Figure-2. Compressive strengths of cement stabilized hollow lateritic blocks.

5.3. Effect of CKD replacement on strengths of blocks

The results of the compressive strengths of lateritic blocks at different proportion of CKD replacement are presented in Figures 3-5. The 28 day strengths of blocks made from 1:8 and 1:10 mix ratios at 10% CDK replacement range from 2.5 N/mm^2 to 2.7 N/mm^2 and meet the minimum requirement of British Standard of 2.0N/mm^2 for non load bearing walls. The strength of 2.7 N/mm^2 of 1:8 mix satisfied the requirement of the Nigerian industrial standard. The 28 day strengths of 1:12, 1:14 and 1:16 however do not meet the minimum standard.

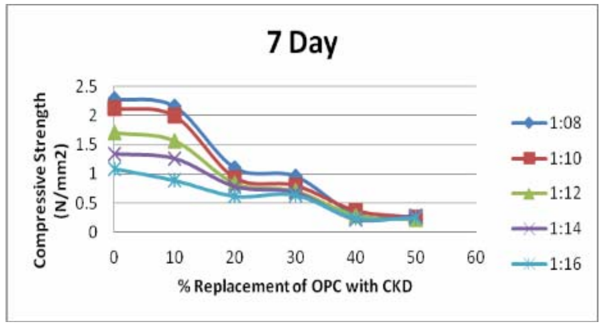

Figure-3. 7 day compressive strength.

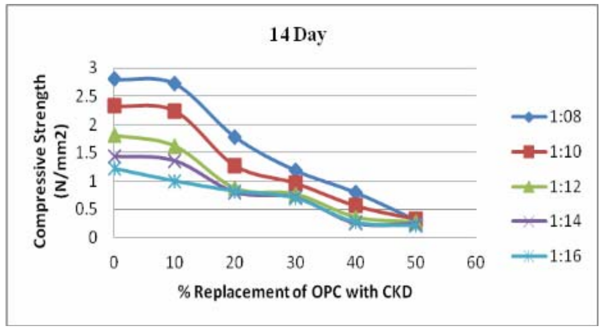

Figure-4. 14 Day compressive strength.

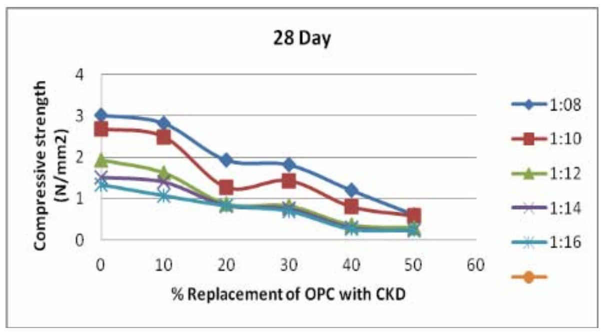

Figure-5. 28 day compressive strength.

CONCLUSIONS

Cement kiln dust and laterite are suitable for hollow blocks making. The compressive strength for all mix decreases with age at curing as the cement kiln dust content increased. Cement kiln dust can be used as a partial replacement of Portland cement in the production of hollow laterized blocks and 10% replacement of OPC by CKD for 1:8 and 1:10 mix was observed to yield maximum compressive strength for them to be use as walling based on NIS and British Standard, beyond this there was a drastic dropped in the compressive strength of the hollow blocks. The optimum replacement level of OPC with CKD for hollow laterized block is 10%.

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