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CEMENT KILN DUST AS A MATERIAL FOR BUILDING BLOCKS

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ABSTRACT

This paper presents the results of a study on the properties of hollow sandcrete blocks with cement kiln dust (CKD) as an additive and as a replacement for ordinary portland cement (OPC). When CKD was used as a replacement for cement, the compressive strength and density of blocks generally decreased with higher replacement levels of OPC by CKD, while the percentage water absorption of blocks increased with higher replacement levels. On the other hand, when CKD was used as additive, within the investigated levels, an improvement in the compressive strength of up to 54% was observed. The density of blocks also increased with higher CKD content as additive, while the percentage water absorption of blocks showed a reverse trend.

Key Words: Kiln Dust, Material, Building, Blocks, Construction

INTRODUCTION

The price of most conventional building materials in many developing countries is so high that the hope of providing adequate shelter for the masses in the nearest future is seemingly slim. Many international agencies that provide assistance to these nations now find that the cost of providing shelter in these countries consumes a large part of their budget. This explains the need for concerted research efforts towards finding alternative building materials in the developing nations. Recycling CKD, a waste by-product of portland cement manufacturing process, into new building material could be a viable solution to the problem of high cost of building material in these nations.

The CKD is abundantly available in most nations, but its possible use in building construction work is limited. More than four million tonnes of CKD, unsuitable for recycling are reported to be disposed off annually in the United State (Todres et al, 1992). It has also been reported that this material, apart from posing storage problems, is a health hazard and a potential source of pollution. Consuming such material in civil engineering structures to upgrade marginal materials would help solve some of these problems (Baghdadi et al, 1995).

As a contribution towards finding a potential use of CKD in building construction work, a research programme was designed to study the effect of kiln dust on some properties of hollow sandcrete blocks when used as an additive and as a replacement for OPC.

MATERIALS

The CKD used in this investigation was obtained at the dumping site within Ashaka Cement Company in Gombe State of Nigeria. The CKD had a specific gravity of 2.61 and showed a wide range of particle size from less than 63μm to 600μm. The chemical composition of the CKD is shown in Table 1. Ashaka brand of cement which is a moderate-low-heat portland cement conforming to ASTMC150 Type II cement was used throughout the investigation. The cement had a specific gravity of 3.15. Sharp river sand obtained from a local supplier was also used for this study. The grain

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size distribution curve of the river sand is also shown in Fig. 1.

PREPARATION OF SPECIMENS AND TEST METHODS

In evaluating the effect of CKD on the properties of hollow sandcrete blocks, specimens of size 440 x 225 x 155mm were produced from a mix ratio of 1:4:0.5 (cement:sand:water-cement ratio). The specimens with CKD as additive were made from batched mortar mixes containing 5, 10 and 20% CKD by mass of cement, while specimens with CKD as replacement for OPC were produced from batched mixes containing 20, 40, 60, 80 and 100% replacement levels of OPC by CKD. Plain specimens with no CKD were also produced for reference purpose.

Compaction of specimens with CKD as additive was by a mechanical table vibrator while specimens with CKD as replacement for OPC was by a manual method. Blocks were trimmed to fit into a motorized compression machine (ELE 2000) and tested for compressive strength at ages of 3, 7 and 28 days. Three specimens were tested for each CKD levels and the average value was taken as the compressive strength. For the water absorption, test specimens were weighed before and after submerging, in water for 24 hours. The difference between the wet mass and the dry mass of blocks expressed as a percentage of the dry mass was noted as the water absorption.

The compaction factor test of batched mixes was in accordance with BS 1881 : Part 2 : 1970, while the density and compressive strength of blocks were in accordance with BS 2028, 1364:1968. The chemical analysis of the CKD used for this work was done using X-ray fluorescence machine in Ashaka Cement Company.

TEST RESULTS AND DISCUSSION

The results of the workability of fresh CKD

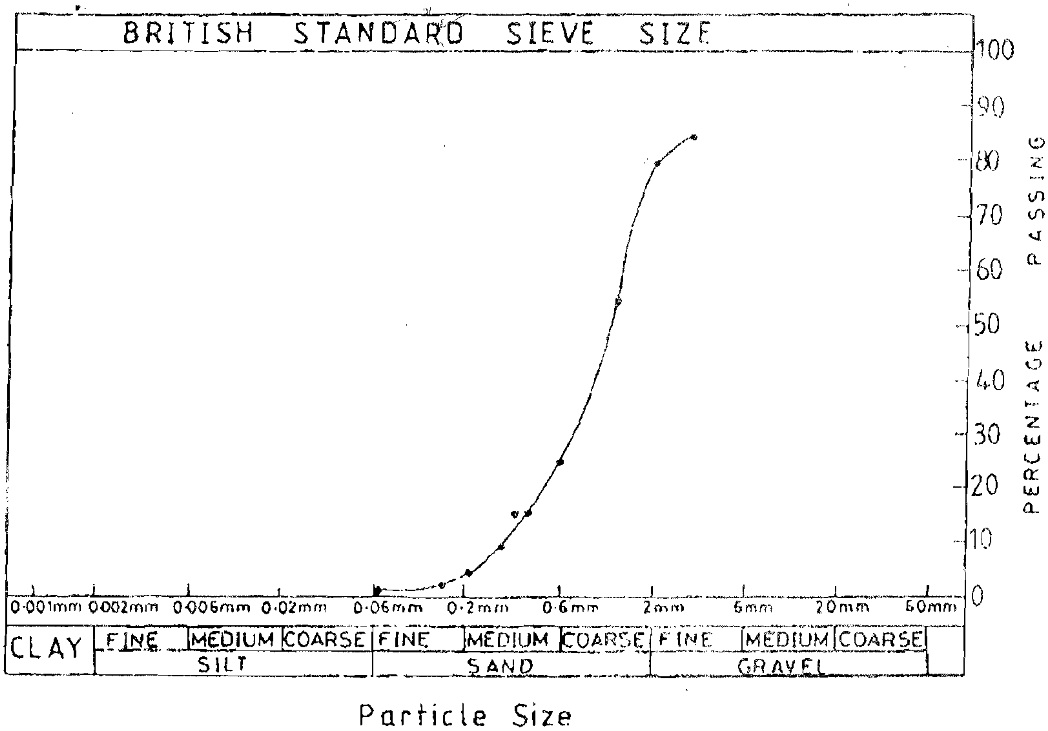

Fig. Grain size distribution curve for sand

Table 1 - Chemical Composition of CKD

Compound (1)	Composition, Percentage: Range (2)	Average (3)
Calcium oxide (CaO)	42.45 - 43.02	42.71
Silica (S_iO_2)	12.90 - 13.83	13.32
Aluminium oxide (Al_2O_3)	4.23 - 4.29	4.25
Iron oxide (Fe_2O_3)	1.87 - 1.90	1.88
Magnesium oxide (MgO)	0.52 - 0.55	0.53
Sulphur oxide (SO_3)	0.71 - 0.78	0.74
Sodium oxide (Na_2O)	0.07	0.07
Potassum oxide (K_2O)	1.10 - 1.12	1.11
Loss on ignition (LOI)	34.07 - 34.50	34.27

Table 2 - Properties of Blocks with CKD as Additive

Percentage of CKD (1)	Workability (compaction factor) (2)	Compressive Strength (N/mm^2) 3rd day (3)	7th day (4)	28th day (5)	Air-dry density (kg/m^3) (6)	Water Absorption (%) (7)
0	0.877	2.66 ± 0.08	3.23 ± 0.71	4.10 ± 0.52	1377.00	5.68
5	0.876	2.64 ± 0.99	3.32 ± 0.21	6.32 ± 0.42	1396.55	6.53
10	0.894	2.91 ± 0.65	3.56 ± 0.33	5.39 ± 0.59	1401.11	5.43
20	0.884	2.91 ± 0.42	3.86 ± 0.83	4.20 ± 0.74	1418.70	4.90
		LSD($\rho = 0.05$) = $1.9 N/mm^2$				

ortar mixes, measured by compaction factor test e presented in Tables 2 and 4. The workability emed to improve with increased CKD contents hen CKD was used as additive while the orkability of CKD mortars with CKD as a replacement for OPC appeared not well defined. The influence of CKD as an additive on the densities of hardened concrete blocks presented in Table 2 will show that the average air-dry densities of blocks slightly increased with increase in the

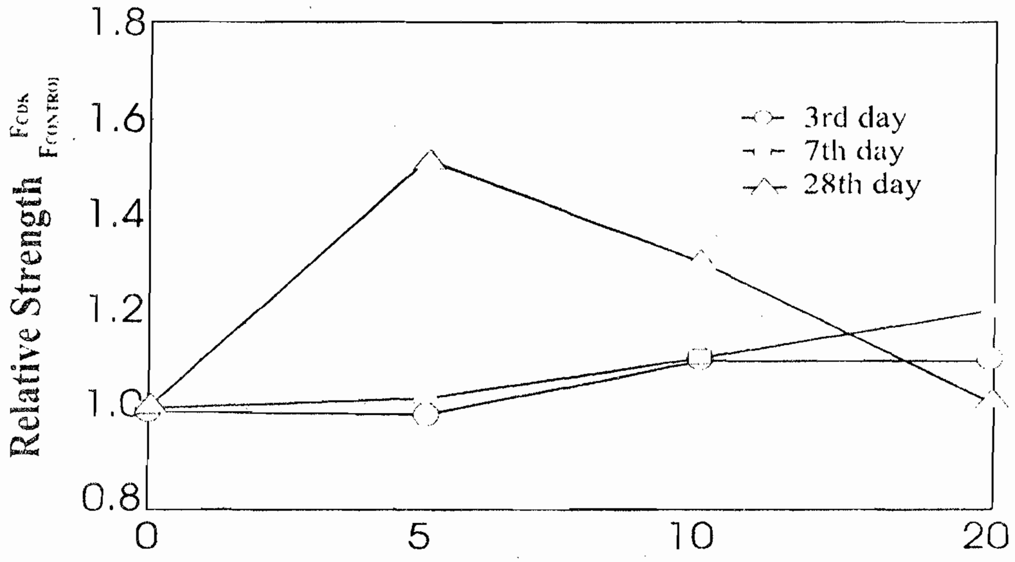

FIG 2 Strength of CKD Blocks Relative to Control Blocks (CKD as Additive)

Table 3 Analysis of Variance For Compressive Strength of Blocks with CKD as Additive

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F - Value	
				Calculated	Tabulated
Additive level	3	10.11	3.37	10.21	4.07
Experimental Error	8	2.62	0.33		
Total	11	12.73			

levels of CKD as additive. The average density for the control samples was 1388.07 Kg/m^3 and increased to 1418.70 Kg/m^3 for blocks with 20% CKD by mass of cement. The water absorption of blocks decreased with increasing levels of CKD. This trend may be due to the infilling of the voids that may exist in the sandcrete blocks by the CKD fines, thus enhancing the blocks pore structure.

The results of the compressive strength of CKD blocks with CKD as additive are presented in Tables 2 and 4. A one-way analysis of variance (Table 3) showed significant difference among the mean 28-day compressive strength of blocks with various levels of CKD as additive. With a computed least square difference (LSD) of 1.9 N/mm^2 at ρ = 0.05 it is evident from the analysis of variance table that the compressive strength of blocks with 5% CKD as additive was significantly higher than the strength of control blocks and that of the blocks with 20% CKD as additive, but insignificantly higher than the strength of blocks with 10% CKD as additive. There was also an insignificant difference between the mean compressive strength of blocks with 10% and 20% CKD as additive.

The strength of blocks with CKD as additive relative to control blocks at various ages are presented in Fig 2. The 28-day strength of blocks increased by 54 ± 11%, 31 ± 14% and 2.0 ± 16% for 5, 10 and 20% levels of CKD, respectively. The improvement in compressive strength of blocks could be as a result of the filler effect of the CKD fines. This is also due to the pozzolanic activity of the silica and alumina present in the CKD with the product of the primary reaction of the OPC and the water used during the production of the blocks. The results of the properties of blocks with CKD as a replacement for OPC presented in Table 4 will show that there was a decrease in the density of blocks with increase replacement level of OPC by CKD. The densities of blocks with 60, 80 and 100% replacement levels reduced by 0.6, 3.6 and 6% respectively compare with the control blocks. This was expected because the specific gravity of CKD was less than that of the OPC replaced in the blocks.

The trend of the compressive strength of blocks with CKD as a replacement for cement generally showed a decreasing value with increasing replacement levels. The compressive strength of blocks with CKD as replacement for OPC relative to the strength of control blocks of the same age shown in Fig 3 indicates that the 28-day strength of blocks decreased by 22 ± 19%, 33 ± 22%, 60 ± 8%, 78 ± 3% and 83 ± 1% for blocks with 20, 40 60, 80 and 100% replacement levels of

Table 4 – Properties of Blocks with CKD as Replacement for Cement

Percentage of CKD	Workability (compaction factor)	Compressive Strength (N/mm^2)			Air-dry density (kg/m^3)	Water Absorption (%)
		3rd day	7th day	28th day		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0	0.877	1.09 ± 0.08	1.49 ± 0.42	3.12 ± 1.15	1749.20	6.47
20	0.868	0.81 ± 0.10	1.0 ± 0.13	2.42 ± 0.58	1688.98	6.33
40	0.878	0.87 ± 0.15	1.28 ± 0.17	2.10 ± 0.70	1749.20	6.73
60	0.893	0.43 ± 0.23	0.60 ± 0.14	1.24 ± 0.25	1738.25	6.30
80	0.889	0.14± 0.02	0.31 ± 0.05	0.70 ± 0.09	1686.24	6.99
100	0.876	0.13 ± 0.03	0.24 ± 0.02	0.52 ± 0.03	1647.92	6.31

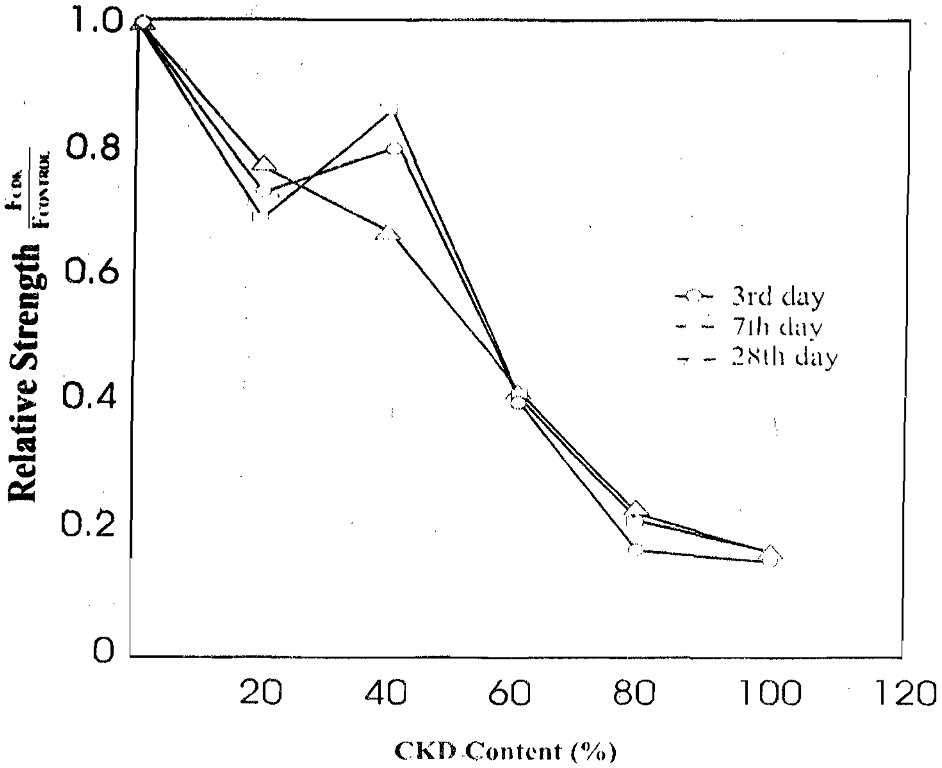

FIG 3 Strength of CKD Blocks Relative to Control Blocks (CKD as partial replacement to OPC)

OPC by CKD, respectively. This implies that a unit mass of OPC replaced by CKD in the mortar matrix for the block contributed more than an equivalent mass of CKD.

Judging by the Federal Ministry of Works of Nigeria requirements for acceptance of block, which states that the average compressive strength for three blocks shall be not less than the specified value of 2.5 N/mm^3, and that the lowest compressive strength of any individual blocks shall be not less than 80% of the specified value, blocks with CKD as additive within the investigated levels in this work could be used for building construction purpose. The values of compressive strength obtained for these blocks were found to lie within the BS 2028, 1364:1968 specified limit for type A(3.5) blocks.

CONCLUSION

A laboratory investigation on the use of cement kiln dust as a block-making material was conducted. From the results of the study the following conclusions are drawn:

1. Hollow sandcrete blocks with 5, 10 and 20% CKD by mass of cement as additive had compressive strength values higher than that of the control, and fall within BS specified limit for type A(3.5) block.

2. The compressive strength of hollow sandcrete blocks with CKD as a replacement for OPC generally showed a decreasing trend with increased CKD content. The values of the compressive strength of blocks with CKD as a replacement for OPC within the investigated levels in this work were less than the specified value by the Federal Ministry of Works of Nigeria.

3. Cement kiln dust, within the investigated additive level, should be used as block moulding material for low cost housing in rural communities, where CKD is available. However, prior to full application of this material in construction, there is need to investigate other properties such as shrinkage, short-term and long-term durability.

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REFEFERENCES

Baghdadi, Z. A.; Fatani, M. N. and Sabban, N. A. 1995. "Soil Modification by Cement Kiln Dust". J. Mat. In Civ. Engrg., ASCE, 7(4): 218 – 222.

British Standards Institution. Methods of Testing Fresh Concrete. BS1881: Part 2: 1970.

Precast Concrete Blocks. B. S. 2028, 1364:1968. BRITISH Standard Inst., London, England.

Tores, H. A.; Mishulovich, A. and Ahmad, J., 1992. Cement Kiln Dust Management Permeability. Res. and Devel., Bull. RD 103, Portland Cement Asocaition, Skokie ill.