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SUITABILITY OF MAIZE COB ASH AS A PARTIAL REPLACEMENT OF CEMENT IN SANDCRETE BLOCKS

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ABSTRACT: This research is aimed at determining the suitability of the use of Maize Cob Ash as partial replacement of ordinary Portland cement (OPC) in the production of Sandcrete Blocks. The maize cob used in this study was sourced from Jengre village in Bassa Local Government Area of Plateau State. The maize cobs were properly dried and burnt to ashes completely at the temperature of 500-600°C in a furnace. Mix ratio of 1:6 (cement: sand) was used in this study. Water cement ratio of 0.5 was adopted in this study. OPC was partially replaced with maize cob ash (MCA) in varying percentages of 10%, 20% and 30% by weight. The block samples were moulded and cured for 7, 14 and 28 days. The compressive strengths of the blocks were tested by crushing using compressive test machine. The compressive strength of the blocks was observed to increase with increasing days of curing. Sandcrete block samples made with 10% and 20% replacements of OPC with MCA achieved compressive strengths of 4.05N/mm^2 and 2.65N/mm^2 respectively at 28 days. These satisfied the minimum compressive strength requirement of 3.45N/mm^2 and 2.5N/mm^2 for load bearing and non load bearing walls respectively specified by NIS:87 (2004) for sandcrete blocks. Blocks made at 10% and 20% percentage partial replacements of OPC with MCA also satisfied the maximum water absorption requirement of 12% specified by Nigeria Industrial Standard (2004) for sandcrete blocks. It is thus recommended that OPC should be partially replaced with 10% and 20% MCA in sandcrete block production for load bearing walls and non-load bearing walls respectively.
Key Words: Maize cob ash, Sandcrete block, partial replacement of cement, compressive strength, Water absorption.

INTRODUCTION

Sandcrete blocks are composite materials made up of cement, sand and water moulded into different sizes. Sandcrete blocks are the commonest walling units used in building construction in Nigeria (Olufisayo, 2013). In Nigeria, cement is the most expensive constituent in the production of sandcrete blocks (Raheem & Sulaiman, 2013). Okafor and Ewa (2012) also identified cement as the most expensive constituent needed in sandcrete block production. High cost of cement is blamed as the main cause of poor quality blocks produced by block industries in Nigeria as they reduce the quantity of cement required for block production in order to reduce cost and make the blocks more affordable. The need to reduce the cost of binder has led to researches into the applicability of various agricultural and mineral pozzolanas as partial replacements of cement in sancrete block production. A pozzolana is described as siliceous and aluminous materials which in itself have little cementitious properties but in finely divided form and in the presence of moisture, can react with calcium hydroxide which is liberated during the hydration of Portland cement at ordinary temperatures to form compound possessing cementitious properties (ASTM C618, 2000). The researches into the applicability pozzolanas in sancrete blocks showed that up to 20% cement could be partially replaced with pozzolanas. Apata and Alhassan (2012) studied locally available pozzolanic materials and concluded that cement could be substituted by at least 10% locally available Pozzolana for low cost housing. Study by Anowai and Afunanya

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(2017) showed that the optimum replacement of cement with millet husk ash in Sandcrete block is 20%. Aginam, Onodagu and Nwakaire (2013) concluded in their study that rice husk ash can be utilized in manufacturing building blocks which are more economical and more eco-friendly than the cement concrete blocks. Infact, Okpala (1993) found that for sandcrete blocks of mix 1:6 (cement: sand) ratio 40% cement replacement with rice husk ash and for mix 1:8 ratio cement replacement of up to 30% with rice husk ash are adequate for sandcrete block production. Mahmoud, Belel and Nwakaire (2012) found that groundnut shell ash could be used as a partial replacement of cement in sandcrete block to achieve a satisfactory compressive strength at a 20 percentage of the binder quantity. In addition to reduction in cost of sandcrete blocks, use of pozzolanas in sandcrete block can reduce the environmental harzards caused by cement production process. Cement has been reported to be among the largest carbon dioxide emission sources to the environment. Almost 5-7% of global carbon dioxide emissions are caused by cement plants, while 900 kg of carbon dioxide is emitted to the atmosphere for producing one ton of cement (Benhelal, Zahedi, Shamseai and Bahadori, 2013). Because of the significant contribution of cement production to the environmental pollution, reduction in cement production and consumption by partially replacing it with pozzolanic material in sandcrete blocks will result to a safer environment. Maize cob is an agricultural waste product obtained from maize production. Maize cob is the hard thick cylindrical central core of maize which carries the grains. The maize cobs are usually discarded after removing the grains. Nigeria is the second largest producer of maize after South Africa in the African continent (Mujedu, Adebara, and Lamidi (2014). Large production of maize translates to generation of large quantity of maize cob as waste product yearly. The maize cob constitutes an environment nuisance in the area where they are disposed. This study investigates the suitability of maize cob ash as a partial replacement of ordinary Portland cement in sandcrete blocks production. The use of maize cob as partial replacement to cement will provide an economic use of this agricultural waste products and also produce cheaper blocks for low cost buildings.

MATERIALS AND METHODS

The fine aggregate used in this research work was clean river sand sourced from Jos, Plateau State, Nigeria. The specific gravity of the fine aggregate is 2.59. Sieve analysis result show that the sand falls within the grading limits of zone 2 of BS 882 (1992) and as such is considered suitable for saandcrete block production. The cement used in this study was "Elephant" brand of 42.5 grade ordinary Portland Cement satisfying the requirements of BS 12 (1991). The specific gravity of the cement was found to be 3.15. The Maize cob used for this research was obtained on a farm land in Jengre Village in Bassa Local Government Area of Plateau State. The Maize Cob was burned in a kiln at a temperature of 500-600°C. The resulting maize cob ash (MCA) was grounded and then sieved through 150μm sieve to give it a fine and smooth texture. The Specific gravity of MCA was found to be 2.38 and falls within the recommended range for pozzolana which is 1.9 – 2.4 (Neville, 1995). The chemical analysis of MCA was conducted using Energy Dispersive X-ray Fluorescence Spectrometer (EDXRF). The water used for this study

was clear drinking water conforming to the specifications of BS 3148 (1980). For the purpose of this work 225mm x 225mm x 450mm hollow

sandcrete blocks were produced using vibrating block moulding machine. The materials used for the production of the blocks were sand, maize cob ash, water, and OPC. The water-cement ratio used in this research was 0.5. Mixes of 1:6 (Cement : Sand) at 0%, 10%, 20% and 30% replacements of cement with Maize Cob Ash (MCA) were adopted in this study. The quantities of materials for each mix was calculated and batched by weight with the aid of weighing balance. The cement, maize cob ash, and sand were mixed manually together to obtain a homogenous mixture. The measured quantity of water was then sprinkled on the mixture using bucket to ensure workability of the mixture. The mixture was turned with shovels until a mix of required workability was obtained. The resulting mortar was filled into the moulds of the moulding machine and vibrated to ensure adequate compaction. After moulding the blocks on wooden palette were removed from the block moulding machine and placed on the ground. After 24 hours on the ground, the block samples were cured by regular sprinkling of water to maintain the moisture needed for hydration of cement. The blocks were cured for 28 days. The compressive Strength tests on the blocks were conducted at 7, 14 and 28 days curing periods. Water absorption tests were conducted on the block samples after 28 days curing period in accordance with the procedure specified by NIS:87 (2004).

RESULTS AND DISCUSSION

Chemical Composition of MCA

The result of chemical analysis of Maize Cob Ash is presented in Table 1. The result of chemical analysis of MCA shows that the sum of Silicon Oxide (SiO_2), Aluminium Oxide (Al_2O_3) and Iron Oxide (Fe_2O_3) is 88.48% which is far above the 70% minimum specified by ASTM C618 (2000) for pozzolanas. The loss on ignition is 4.59 which is less than the maximum value of 12 specified by ASTM C618 (2000). These results confirm that MCA sourced from Jengre Village in Bassa Local Government Area of Plateau State is pozzolanic and can be used as partial replacement of cement in sandcrete block production.

Table 1: Result of Chemical Analysis of MCA

Constituent	Composition (%)
Silicon Oxide (SiO_2)	61.53
Aluminium Oxide (Al_2O_3)	18.28
Iron Oxide (Fe_2O_3)	8.67
Calcium Oxide (CaO)	3.03
Potassium Oxide (K_2O_3)	2.56
Manganese Oxide (Mn_2O_3)	1.72
Titanium Oxide (TiO_2)	0.54
Copper Oxide (CuO)	0.26
Loss on Ignation	4.59

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Water Absorption Test Results

The results of water absorption test on the block samples are presented in Table 2. The results indicate that the water absorption rate increases as the percentage replacement of MCA increases. According to NIS:87 (2004) the water absorption of sandcrete blocks shall not exceed 12%. All blocks made at different percentage replacements of OPC with MCA satisfied this requirement except samples with 30% partial replacement OPC with MCA which exceeded the maximum requirement.

Table 2: Results of Water Absorption Test

Block size (mm)	Percentage of Maize Cob Ash	Dry weight W_1 (Kg)	Wet weight W_2 (Kg)	Water absorption (%) $=\frac{W2-W1}{W2} \times 100$
450x225x225	0	3.92	4.35	9.89
450x225x225	10	3.99	4.47	10.74
450x225x225	20	4.02	4.51	10.87
450x225x225	30	4.10	4.67	12.22

Compressive Strength Test Results

The results of the compressive strength test are as presented in Figure 1. It could be observed that for all the percentage replacements of OPC with MCA, the strength increased with curing age but also reduced with increased percentage replacement of OPC with MCA. After 28 days of curing, the compressive strengths of sandcrete block samples with 10% and 20% OPC replacement levels were 4.05N/mm^2 and 2.65N/mm^2 respectively. These values met the minimum compressive strength requirement of 3.45N/mm^2 for sandcrete blocks to used in load bearing walls and 2.5N/mm^2 for non-load bearing walls specified by the NIS:87 (2004).

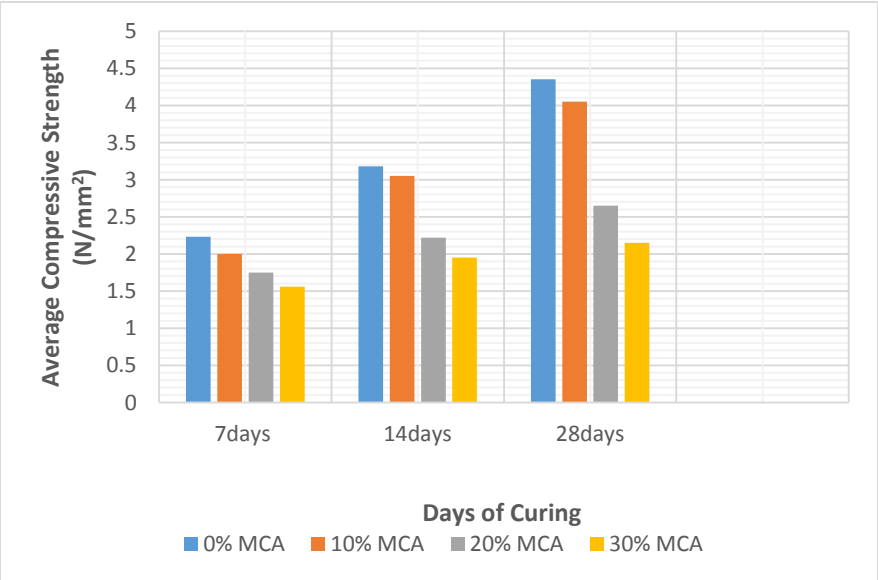

Figure 1: Average Compressive Strengths of Blocks against Days of Curing

SUMMARY OF FINDINGS

The following findings were drawn from this research work. The Maize cob sourced from Jengre Village in Bassa Local Government Area of Plateau State is pozzolanic and suitable for use as partial replacement of cement in sandcrete block production. Sandcrete block samples with with 0 and 10% replacements of OPC with MCA satisfied the minimum compressive strength requirement of 3.45N/mm^2 specified by NIS:87 (2004) for sandcrete blocks to used in load bearing walls while blocks samples with 20% OPC replacement level met minimum compressive strength requirement of 2.5N/mm^2 specified by the NIS:87 (2004) for non load bearing walls. All blocks made at different percentage replacements of OPC with MCA satisfied the maximum water absorption requirement 12% specified by Nigeria Industrial Standard (2004) except samples with 30% partial replacement OPC with MCA which exceeded the maximum requirement.

CONCLUSION

Based on the findings of this research, It can be concluded that maize cob ash is pozzolanic and suitable as partial replacement of cement in the production of sandcrete blocks and the optimum replacement percentage is 10% for load bearing walls and 20% for non-load bearing walls.

RECOMMENDATIONS

Partial replacement of cement with 10% maize cob ash is recommended for use in the production of sandcrete blocks for load bearing walls. Partial replacement of cement with 20% maize cob ash is recommended for use in the production of sandcrete blocks for non load bearing walls.

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