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CRUSHING STRENGTH OF CONCRETE USING MAIZE COB ASH CEMENT AS BINDER

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ABSTRACT
Maize cob is an agricultural waste, which contain high percentage of silica. Due to this high silica content, an attempt had been made to produce maize cob cement (MCC) by mixing maize cob ash with lime slurry. The dried product was burnt at temperature of 1250^0C. Four categories of MCC were prepared by varying the lime slurry in the mixture. The fineness, setting time and soundness tests were carried out on the MCC while workability and strength tests were carried out on the maize cob concrete. For each category of MCC, three 100mm x 100mm concrete cubes were cast and tested for strength at 3, 7, 28, and 56 days hydration period respectively. All the four categories of MCC showed tendency for expansion but the one with least expansion was adopted. The optimum strength obtained was 22 N/mm^2 at 28 days for the cement consisting of one part maize cob ash and one part lime and this could be used for structural works in construction where low strength is required.

Introduction

Nigeria is a developing country that relies on imported materials for her housing and other developments: one of such materials is cement. Though produced locally much importation is also made to meet the demands for construction industries. This requires hard currency and a drain on the nation`s resources. There is therefore the need to look inward for the development and use of local raw materials which can serve as partial or total replacement of cement in construction activities. Viable alternative materials should be locally available, stable in raw material cost, cheap in conversion and easy to understand and used. Previous research works by Okpala (1987), Samaila and Job (1999), Dashan and Kamang (1999) investigated the use of ashes from rice husk, saw dust and Acha husk respectively as a partial replacement of cement while the unpublished work by Kwami (2001), Eromosele (2003) also shows that MCA could be used for partial replacement of cement in concrete and plaster works respectively. All the efforts of these researchers were towards the economic reduction of the quantity of cement required in the mix. Kong and Evans (1989), Nevielle (1981) observed that the essential and main cementitious compound in the composition of cement are tricalcium silicate $3CaO.SiO_2$ or (C_3S) and dicalcium silicate $2CaO.SiO_2$ or (C_2S) with approximate quantities of 45% and 25% respectively. Chemical analysis of maize cob ash shows that the percentage of silica oxide present in it is 60% (see Table 1) compared to ordinary portland cement (OPC) with 25%. The maize cob is an agricultural waste which is often discarded after the grains had been removed. Due to this high percentage of silica present in maize cob ash, this paper measure the strength of concrete that can be produced by using maize cob cement which is a combination of maize cob ash and factory produced lime as a total replacement of OPC in concrete works.

Materials and Methods

The maize cobs for this research were obtained within the Federal University of Technology Yola and its environs. The cobs were dried in the sun and all deleterious substances attached to the cob were removed. The dried cobs were fed into a 200 litre

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capacity drum and burnt to ashes. The maize cob ash (MCA) was further burnt in an oven at a temperature of 750^0C. After cooling, the sample was analysed for its chemical composition at the Nigerian mining corporation Jos. The result of the chemical composition is shown in Table 1. The specific gravity was determined and shown in Table 2.

Lime slurry was prepared by mixing lime and water, this mixture was left overnight to cool due to the heat being generated. The following proportions on weight basis of maize cob ash to lime slurry content were adopted to produce four different categories of maize cob cement (MCC) and these are:

A : one part maize cob ash to one part lime
B : one part maize cob ash to two parts lime
C : one part maize cob ash to three parts lime
D : one part maize cob ash to four parts lime

The maize cob ash and lime slurry were mixed together to obtain a uniform mixture by hand mixing. These mixtures were exposed to the sun for complete drying. The dried mixture was fed into a vertical kiln and burnt to ash at a temperature of 1250^0C. The ash was pulverized to the fineness of cement to pass through 75micron of the BS sieve. The specific gravity for the four categories of MCC were determined and the results shown in Table 2. Absolute volume method was used to design the concrete mix ratio (1:2:4). Ratio 1:2:4 was adopted because it is versatile. The fine aggregate used in the mix was river sand and for grading purposes, only grades that were retained on sieves up to 2.38mm sieve size were chosen. Those retained on 5mm sieve were excluded because they can be classified as either fine or coarse aggregate. To ensure removal of impurities, the sand was flushed with water and later dried. The coarse aggregates used were crushed stone obtained within Yola. Coarse aggregate retained on 10mm sieve were used. The coarse aggregate were flushed with water and dried. The specific gravity for the aggregates was determined and the results shown in Table 2. Using water/MCC ratio of 0.5, concrete cubes for each category of cement were prepared in 100 mm x 100 mm moulds and these were cured in water for prescribe periods and tested for strength.

Setting Time

Paste of MCC was prepared by mixing MCC and water. The water used for the preparation were 26.5%, 27%, 28%, and 29.5% by mass of the dried MCC for the four categories A,B,C, D of the MCC. Using the Vicat apparatus, the initial and final setting time were determined. (See Table 3)

Soundness

Similar preparation of MCC paste used for the determination of setting time was done and with the aid of Le Chartlier apparatus, the soundness was determined according to the provision of BS 4550 for the four categories of MCC. Table 4 shows the results.

Workability

The workability for each mix was determined using both the slump and compaction factor test in accordance to the provision of BS 1881 part 102 and 103 respectively. Table 5 shows the result.

Compressive Strength

Using the four categories of MCC separately, four types of concrete were prepared using hand mixing. Three 100mm cubes are made one at a time for each type of MCC in 100mm x 100mm metal moulds. The cubes were demoulded after 24 hours and further

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cured in water until tested in a wet surface condition at 3, 7, 28 and 56 days hydration periods. After the desired hydration periods the cubes were cleaned and tested on a 1560KN compression testing machine. (see Table 6 for the result).

Presentation of Results and Discussion

The maize cob is that part of maize on which the grains grow and is often discarded as waste after the grains have been removed constituting a large amount of waste. International Institute of Tropical Agriculture (2002) reported that maize is currently produced in most countries of the world and is the third most planted field crop after wheat and rice. Reports from the FAO (2000) shows that about 590million tones are produced world wide of which Africa produces 41.3million (7%) tonnes with Nigeria producing about 5.5million tonnes of the Africa's production. It can be seen that enormous waste of maize cobs is available after the grains had been removed. It is therefore the utilization of this waste that is of interest in this paper. In Table 1, the chemical composition of MCA as shown is similar to the approximate composition limits given by Nevielle (1991) but significant differences are in silicon oxide (SiO_2) and calcium oxide (CaO). The percentage of SiO_2 is 60% in MCA while that of OPC is 17 – 25 % and the percentage of CaO is 2.46 in MCA while that of OPC is 60 – 67 %. Table 2 shows the specific gravity for the materials used for the preparation of the concrete mix.

The fineness to which the MCC has been prepared was determined by sieve analysis and it was found that all the particles pass through No.170 sieve with 90 microns aperture width and 98% pass a No. 200 with 75microns. These fineness of the MCC is similar to those expected for OPC. In Table 3, the initial and final setting time are shown and it can be observed that the setting time for all the categories of MCC are within the period prescribed for OPC in BS 12. In Table 4, the result of the soundness for the four categories of MCC are shown. Le Chartelier apparatus was used because it is capable of detecting unsoundness due to free lime. The MCC with the least expansion is preferable to others because the free lime present in the cement will hydrate very slowly and the expansive reaction may continue for months or even years after the cement has set causing cracking and disintegration of the mass and the security of any concrete structure with which such cement has been used could not be guaranteed. In Table 5 the result obtained for the workability test are shown. Workability is intimately related to compatibility, mobility and stability of the concrete among others. In the table, slump test was used to measure the mobility and stability while compaction factor test was used to measure the compatibility of the concrete in accordance with the provisions of BS1881 parts 102 and 103 respectively. The results are within permissible range similar to those reported by Kong and Evans (1987).

Table 6 shows the results of the crushing strengths obtained at 3, 7, 28 and 56 days hydration periods for the four categories of MCC. The four categories of MCC shows that strength growth is noticeable as the curing period increases. However, It could be seen in the four categories of the mix that as the lime content increase from A to B, there is strength increase, but as the lime content increase from B to C and C to D there is a reduction in strength. The optimum strength of the concrete is obtained when the mix composition consists of one part MCA to one part of lime at 28 days.

Conclusion

Maize cob often discarded as agricultural waste are available in large quantities in Nigeria and can be processed and used as cement in concrete works where low strength up to $20N/mm^2$ is required for structural concrete The technology for the production of the cement is not intricate and can easily be mastered.

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Table 1 Chemical composition of Maize cob ash

CONSTITUENTS	PERCENTAGE COMPOSITION
SiO_3	60.10
Al_2O_3	7.20
Fe_2O_3	5.50
CaO	2.46
MgO	2.68
K_2O	0.14
Na_2O	0.18

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Table 2 Specific Gravity for materials

MATERIAL	SPECIFIC GRAVITY
Sand	2.60
Stone	2.65
Maize Cob Ash	2.0
A (1:0.5)*	2.6
B (1:1)	2.8
C (1:2)	2.9
D (1:3)	3.0

* ratio of MCA to lime

Table 3 initial and final setting times of paste

Mix proportion	Initial setting Time Hours, minutes	Final setting Time Hours, minutes	Water content for MCC paste (%)
A	1,30	3,15	26.5
B	1,45	3,20	27
C	2,00	3,30	28
D	2,15	3,45	29.5

Table 4 Cement expansion

Maize cob cement type	Expansion (mm)
A	1.5
B	1.0
C	2.5
D	2.2

Table 5 workability of concrete made with maize cob cement

Mix proportion	Slump (mm)	Compacting Factor
A	20	0.85
B	23	0.85
C	25	0.88
D	28	0.90

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Table 6 Strength development of concrete (N/mm^2)

Hydration period / Maize cob Cement type	3 days	7 days	28 days	56 days
A	4	7	15	17
B	6	10.5	22	24
C	5	8.8	18	20
D	3.5	6	14	15