Effects of Admixtures on the Properties of Corn Cob Ash Cement Concrete

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Abstract

The study investigated the effects of admixtures on the properties of corn cob ash (CCA) cement concrete. The workability and compressive strength of CCA cement concrete incorporated with accelerator, plasticizer and water reducing and retarding were carried out. The dosage of admixture incorporated was: 0.124litre per 15.55kg of cementitious material based on the recommendation by BS EN 934-2.The results revealed that admixtures generally improve the workability of corn cob ash cement concrete. The compressive strength obtained at 28th day for concrete without admixture (The Control) was 29.82N/mm2, while for concrete with accelerator, plasticizer, and water reducing and retarding it was 32.80 N/mm2, 38.51 N/mm2 and 34.09 N/mm2 respectively. These results showed that CCA cement concrete incorporated with accelerator achieved greater strength at early ages. With plasticizer, it achieved very high strength at both young and old ages; while with water reducing and retarding it achieved greater strength at old ages alone.

Keywords

Admixtures; Corn cob ash (CCA); Workability; Compressive strength.

Introduction

Admixtures are substances introduced into a batch of concrete, during or immediately before its mixing, in order to alter or improve the properties of the fresh or hardened concrete or both. According to Neil and Ravindra [1], numerous benefits are available through the use of admixtures such as: improved quality, acceleration or retardation of setting time, coloring, greater concrete strength, increased flow for the same water-to-cement ratio, enhanced frost and sulfate resistance, improved fire resistance, cracking control, lower density, improved workability and enhanced finishability. The changes brought about in concrete by the use of admixtures are affected through the influence of the admixtures on hydration, liberation of heat, formation of pores and the development of the gel structure [2]. The specific effects of an admixture generally vary with the type of cement, mix proporition, ambient conditions (particularly temperature) and dosage.

Corn cob is the agricultural waste product obtained from maize or corn, which is the most important cereal crop in sub-Saharan Africa. According to Food and Agriculture Organisation (FAO) data, 589 million tonnes of maize were produced worldwide in the year 2000 [3]. The United States was the largest maize producer having 43% of world production. Africa produced 7% of the world's maize [4]. Nigeria was the second largest producer of maize in Africa in the year 2001 with 4.62 million tonne. South Africa has the highest production of 8.04 million tonne [3].

There had been various research efforts on the use of corn cob ash (CCA) as a pozzolan in blended cement concrete. Ogunfolami [5] considered mixing of the CCA with Ordinary Portland Cement at the point of need i. e. on site. Adesanya and Raheem [6] studied the use of CCA blended cement produced in the controlled environment of a factory as reported by [7], to produce concrete specimens. Both studies concluded that the compressive strength of the CCA-blended cement concrete is lower than that of plain concrete (the control) at early curing ages but improves significantly at later ages (after 90 days). Thus, there is need to look for ways of increasing the strength at early ages. This study investigated the incorporation of admixtures into CCA blended cement concrete with a view to enhancing its suitability as a structural material.

Admixtures are commonly classified by their functions in concrete into seven types, as specified in ASTM C 494 (1992) [8] viz:

Type A	Water reducing
Type B	Retarding
Type C-	Accelerating
Type D	Water – Reducing and Retarding
Type E	Water-Reducing and Accelerating
Type F	High-range water-reducing or Superplaticizing
Type G	High-range water-reducing and Retarding or Superplastcizing and retarding

For the purpose of this study, Type C (Accelerating Admixtures), Type D (Water reducing and retarding Admixture), and Type F (Superplasticizing Admixtures) were considered.

Experimental Procedure

Materials

The CCA blended cement used was produced in accordance with the procedure set out in [7]. The chemical composition of CCA [as obtained from previous study (7)], which makes it possible to be used as a pozzolan, is presented in Table 1. Sharp sand was used as fine aggregates and granite as coarse aggregates. The fine and coarse aggregates used were obtained from Ogbomoso, Nigeria. The grading curve for the sharp sand used is shown in Figure 1 while that of the granite is shown in Figure 2. The admixtures used are: Accelerator [Pozzolith 555], Water Reducing and Retarder (Conplast RP264) and Superplasticizer (SP-3).

Table 1. Chemical composition of corn cob ash (CCA)

Chemical Constituents	Composition (%)			
	Sample 1	Sample 2	Sample 2	Average
SiO_2	67.33	65.39	66.41	66.38
Al_2O_3	7.34	9.14	5.97	7.48
Fe_2O_3	3.74	5.61	3.97	4.44
CaO	10.29	12.89	11.53	11.57
MgO	1.82	2.33	2.02	2.06
SO_3	1.11	1.10	1.01	1.07
Na_2O	0.39	0.48	0.36	0.41
K_2O	4.20	4.92	5.64	4.92
$S1O_2 + Al_2O_3$	74.67	74.53	72.38	73.86

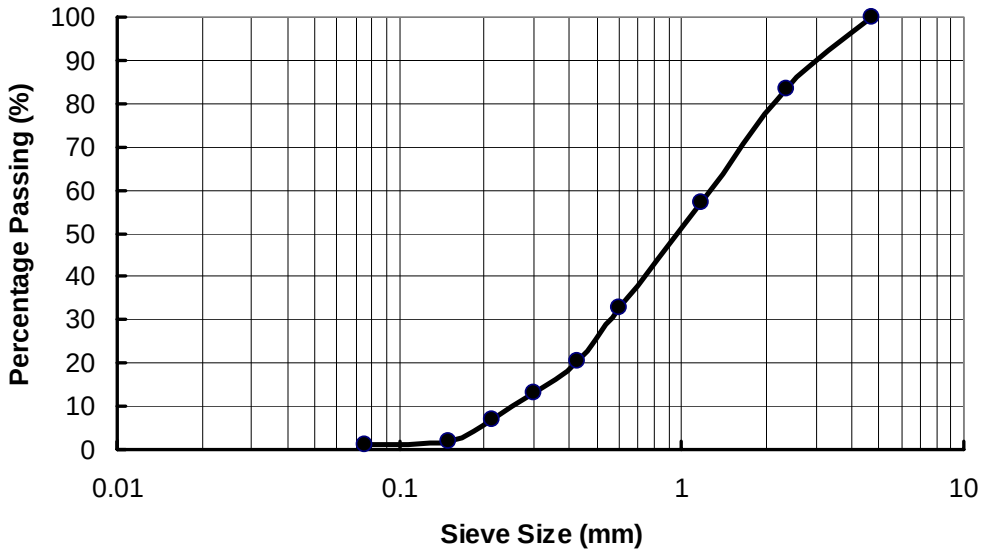

Figure 1. *Particle size analysis for the sharp sand used*

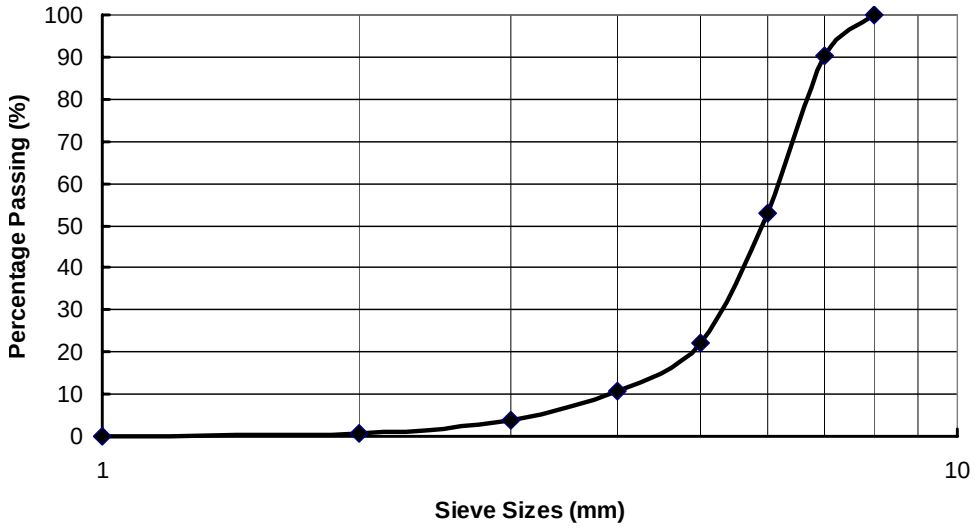

Figure 2. *Grading curve for the granite used*

Specimen Preparation

The weight method of batching was adopted throughout. The mix ratio for the concrete is 1: 2: 4 and the dimension of mould is 150mm × 150mm × 150mm. The CCA was 8% by weight of cement used since a previous study [6] reported that the optimum level of CCA replacement from structural load viewpoint is 8%. The dosages of admixtures incorporated were: 0.124 litre of accelerator, water reducing and retarder and plasticizer per 15.55kg of cementitious material based on the recommendation by BS EN 934 -2 [9].

The required quantity of cement and corncob ash were first mixed then, sharp sand was added and thoroughly mixed until a uniform distribution was obtained. Granite was then added and mixed until a fairly uniform appearance was observed. Water was gradually added and the mix was thoroughly mixed until uniform appearance in colour and consistency was obtained. This served as the control experiment. For the other experiments, the above procedure was repeated until when water is to be introduced. Water, together with the required dosage of each admixture was then added and the composites thoroughly mixed until uniform colour and consistency was obtained. Constant water/ cementitious material ratio of 0.55 was adopted throughout.

Testing Procedure

Slump test was carried out to check the effects of admixtures on the workability of corn cob ash cement concrete. The test was carried out in accordance with the requirements of BS 1881: Part 102 (1983) [10]. For compressive strength test, a total of 60 cubes were cast for the four experiments. After casting, the specimens were stored in the curing room at 27 ± 5^{o}C with 90% relative humidity for 24hours and then demoulded and placed under water until the testing ages of 1, 3, 7, 14 and 28 days. The compressive strength was determined with CONTEST Compressive Strength Testing Machine (Type GDIOA, Serial Number 3688) with maximum capacity of 2000KN. The strength value was the average of three specimens.

Results and Discussion

Workability

The results of the slump for the four classes of corn cob ash cement concrete are shown in Table 2.

Table 2. Slump Test Results

Class of Concrete	Slump (mm)
Concrete without Admixture	28.5
Concrete with water reducing and retarder	29.6
Concrete with Accelerator	32.4
Concrete with Plasticizer	35.5

The table indicates that the concrete slump increases with the incorporation of admixtures. While the control has a slump of 28.5mm, concrete with Water reducing and retarder, Accelerator and Plasticizer has slump of 29.6mm, 32.4mm and 35.5mm respectively. This finding is in agreement with the report of Kosmatka et al. (2003) [11] which stated that adding an admixture to concrete without reducing the water content (i.e. with constant w/c ratio) can produce a mixture with a higher slump.These results indicate that admixtures generally improve the workability of corn cob ash cement concrete. The greatest effect was caused by the plasticizer. This is due to the fact that it improves the flow properties of the mix by dispersing the cement particles and breaking up cement agglomerate.

Compressive Strength

The results of the compressive strength of corn cob ash cement concrete are presented in Table 3. The compressive strengths obtained at 1^{st}, 3^{rd}, 7^{th}, 14^{th} and 28^{th} days for concrete cubes without Admixture (The Control) were 10.42 N/mm^2, 12.71 N/mm^2, 15.30 N/mm^2, 21.85 N/mm^2, and 29.82 N/mm^2 respectively. For concrete cubes with Accelerator, they were 13.19 N/mm^2, 15.40 N/mm^2, 17.33 N/mm^2, 24.89 N/mm^2 and 32.80 N/mm^2 respectively. For concrete cubes with Plasticizer, they were 15.31 N/mm^2, 17.42 N/mm^2, 19.56 N/mm^2, 27.84 N/mm^2 and 38.51 N/mm^2 respectively and for concrete cubes with Water reducing and retarder they were 12.07 N/mm^2, 15.39 N/mm^2, 17.88 N/mm^2, 25.78 N/mm^2, and 34.09 N/mm^2 respectively. The NIS 439:2000 [12] requirements for minimum compressive strength of $26Nmm^{-2}$ at 28 days were satisfied by all the classes of concrete. The incorporation of admixtures in corn cob ash cement concrete generally improves its compressive strength at all ages irrespective of the type used.

Table 3. Summary of Compressive Strength Test Results

Class of Concrete	**1 Day (N/mm^2)**	**3 Days (N/mm^2)**	**7 Days (N/mm^2)**	**14 Days (N/mm^2)**	**28 Days (N/mm^2)**
Concrete Cube without Admixture	10.42	12.71	15.30	21.85	29.82
Concrete Cube with Accelerator	13.19	15.40	17.33	24.89	32.80
Concrete Cube with Plasticizer	15.31	17.42	19.56	27.84	38.51
Concrete Cube with Water reducing and Retarder	12.07	15.29	17.88	25.78	34.09

When compared with the control, the corn cob ash cement concrete incorporated with Accelerator has an increase in compressive strength of 26.6% at day 1, 21.2% at day 3, 13.3% at day 7, 13 9% at day 14 and 10% at 28 days. This is because, accelerator increases the

hydration of the cement and depresses the freezing point of concrete by no more than 2^0C which speed up the setting and rate of strength gain thereby making the concrete stronger. This is in line with the findings of Neville (1996) [13]. The effect is more pronounced at early ages as higher percentages of strength gains were recorded at day 1 and day 3.

For corn cob ash cement concrete incorporated with Water reducing and retarder, an increase in compressive strength of 15.8% at day 1, 20.3% at day 3, 16.9% at day 18.0% at day 14 and 14.3% at 28 days were recorded over that of the control. This result is supported by Kosmatka et al. (2003) [11], which noted that for concretes of equal cement content, the 28 day strength of concrete with water reducing admixture can be 10% to 25% greater than concrete without admixture. The strength gains recorded in this study for all testing ages, fall within the specified range of 10% to 25%. Lower strength gains were witnessed at early ages (day 1 and 3) while higher strength gains were recorded at later ages (day 7, 14. and 28).

With corn cob ash cement concrete having Plasticizer as admixture, an increase in compressive strength of 46.9% at day 1, 37.1% at day 3, 27.8% at day 7, 27.4% at day 14 and 29.1% at 28 days were observed over that of the control. This showed higher percentage strength increases at early and later ages when compared with the results for Accelerating and Water reducing and retarding admixtures.

Conclusions

From the results of the various tests performed, the following conclusions can be drawn:

1. Admixtures generally improve the workability of corn cob ash cement concrete. The greatest effect was caused by plasticizer which improves the flow properties of the mix by dispersing the cement particles and breaking up cement agglomerate.
2. The incorporation of admixtures in corn cob ash cement concrete generally increases its compressive strength at all ages irrespective of the type used.
3. The use of Accelerator achieved greater strength at early ages. With Plasticizer, high strength was achieved at both young and old ages while with Water reducing and retarder, greater strength was achieved at old ages alone.

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References

1. Neil J., Ravindra K.D., *Civil Engineering Materials*, 5th edition, England, Longman, 1996.
2. Jackson N., Dhir R.K., *Civil Engineering Material*, London, Macmillan, 1996.
3. FAO. Records, Retrieved December 15, 2002, Available at: http://apps.fao.org/default.htm.
4. IITA. Maize, Retrieved December 15, 2002, Available at: http://intranet/iita4/crop/maize.htm.
5. Ogunfolaji T.F., *The Effect Of Thermal Conductivity and Chemical Attack on Corn Cob Ash Cement Concrete*, Unpublished B. Sc. Project Report, Department of Building, Obafemi Awolowo University, Ile-Ife, 1995.
6. Adesanya D.A., Raheem A.A., *A study of the workability and compressive strength characteristics of corn cob ash blended cement concrete*, Construction and Building Materials, 2009, 23, p. 311-317.
7. Adesanya D.A., Raheem A.A., *Development of Corn Cob Ash Blended Cement*, Construction and Building Materials, 2009, 23, p.347-352.
8. American Society for Testing and Materials. Specification for Chemical Admixtures for Concrete, ASTM C 494, 1992.
9. British Standard Institution. Admixtures for Concrete, Mortar and Grouting, BS EN934 - 2, London, British Standard Institution, 2001.
10. British Standard Institution. Methods for determination of Slump, BS 1881: Part 102, London, British Standard Institution, 1983.
11. Kosmatka S.H., Kerkhoff B., Panarese W.C., *Design and Control of Concrete Mixtures*, EB001, 14th edition, Skokie, Illinois, USA, Portland Cement Association, 2003.
12. Standards Organisation of Nigeria. *Standard for Cement*, NIS 439, Lagos, Nigeria. 2000.
13. Neville A.M., *Properties of Concrete*, 4th edition, London, Pitman Publishers Inc., 1996.