THE POTENTIALS OF CASSAVA FLOUR AS A SET-RETARDING ADMIXTURE IN CONCRETE

F. O. Okafor
Department of Civil Engineering
University of Nigeria, Nsukka.

ABSTRACT

The potentials of cassava flour as a set-retarding admixture in concrete were investigated. Concrete mix proportion of 1:2:4 by weight of cement, sand and coarse aggregate and, water/cement ratio of 0.46 was made with six different dosage levels of cassava flour as admixture. The properties tested include setting time, workability of the fresh concrete and compressive strength of the hardened concrete. These properties were compared with those of similar concrete mix made without cassava flour admixture. It was observed that cassava flour considerably improved the workability of the fresh concrete and delayed the setting time of cement by up to 6 hours. Results of the tests also show that while cassava flour reduced the early strength of concrete, the long-term strength was improved. Cassava flour dosage level of 3% was also found to be the optimum level of addition of the admixture.

KEYWORDS: *Admixture; Cassava Flour; Compressive Strength; Retardation; Setting Time; Workability.*

1.0 INTRODUCTION

Set-retarding admixtures are chemical additives for concrete. These admixtures generally delay the setting time and reduce the subsequent rate of hydration of cement. Several compounds have been found to exhibit retarding action in concrete and their performance is covered in the part 1 of the British Standard, BS 5075 [1]. Some of these compounds include soluble zinc salts, soluble borates, sugar and carbohydrate derivatives. The performance of retarding admixtures in concrete has been investigated by many researchers [2 – 16] and has been found to offer several advantages in concrete. Retarders are useful in hot weather concreting to offset the effect of high temperatures, which decrease setting times, or to avoid complications when unavoidable delays between mixing and placing occur. Another important application is in concrete pavement construction [17], where retarders enable farther hauling, thus eliminating the cost of relocating central mixing plants; allows more time for texturing or plastic grooving of concrete; and helps eliminate cold joints in two-course paving.

In Nigeria and many other tropical developing countries, building contractors often shun the use of set-retarders when concreting in hot-dry weather because of the very high cost of the conventional retarding agents usually imported. The consequence of this practice has been the production of low quality or defective concrete structures.

As a contribution towards reversing this trend, the potentials of cassava flour as a set-retarder are investigated. Cassava tubers are very rich in carbohydrate, relatively cheap, produced locally in very large quantities and the production of flour from these tubers does not require any complicated technology.

This paper is a discussion of the results of an investigation on the potentials of cassava flour as a set-retarding admixture in concrete.

2.0 MATERIALS AND PROCEDURES

2.1 Cassava Flour

Fresh cassava tubers were peeled and chopped into thin slices, washed and sun dried to constant weight. The dried cassava chips were then ground to a fine texture in a mill and the flour obtained sieved with BS sieve No. 85 to remove any chaff present in the flour. The processed flour was then stored in plastic bags. Chemical analysis of the cassava flour gave the follow results.

Starch content: *93.24%*

Solubility: *8.6% (8.6 g/100 ml of water)*

pH (1 gm in 100 ml of water): *6.27 (slightly acidic)*

Cyanide content: *4.86%*.

2.2 Cement

The cement used in the investigation is ordinary Portland cement marketed by Dangote (Nig.) Ltd and has successfully been in use for laboratory investigations.

2.3 Aggregates

The grading of the river sand used in the tests conformed to the zone 3 requirements of BS 882 [18]. The coarse aggregate used is natural gravel of lateritic origin with particles size distribution shown in Table 1. The sieve analysis was carried out in accordance with BS 812 [19].

Table 1: Grading of the Coarse Aggregate

Sieve size (mm)	Cumulative % by weight passing
19.05	100
13.20	72
9.50	51
4.75	6
2.36	0

2.4 Preparation of Specimens

The mix proportion adopted was 1:2:4 by weight of cement, fine and coarse aggregate and free water/cement ratio of 0.46. Concrete mixes were prepared with cassava flour admixture dosage of 1%, 2%, 3%, 5%, 7% and 10% by weight of cement. For comparisons of properties of the various concretes, control concrete without admixture was also made.

Mixing and compaction was by hand. The required weight of cassava flour admixture was first mixed with cement followed by the addition of fine and coarse aggregate and then water. Workability measurements were carried out on the various concretes by two of three BS1881 [20] standard test methods (slump and compacting factor).

All test specimens were kept under cover with wet jute bags in the laboratory until demoulding at 24 hours after which they were transferred to curing water at room temperature.

The property of the hardened concrete tested was compressive strength on 100 mm cubes, three samples being tested at each age of 3 days, 7 days, 14 days, 28 days and 56 days.

The setting time of cement for the various dosage level of cassava flour was determined in accordance with BS 4550 [21].

3.0 RESULTS AND DISCUSSION

3.1 Setting Time

The results of the setting time tests are presented in Table 2. The results indicate a markedly delay in both the initial and final setting time of cement by the addition of cassava flour up to 3% of the weight of cement. The delay in the initial and final setting time increases with increase in the dosage level of the admixture. Within the range of 3% dosage level, the delay in the initial and final setting time was of the order of about 5 hours and 6 hours respectively.

However, above 3% level of addition of cassava flour there was a decrease in the initial setting time of cement. While shortening of the initial setting time increases with increase in the dosage level of cassava flour, the trend of the final setting time remains unaffected. The observed acceleration of the initial setting time may be attributed to the increased cyanide content of the cement due to the increased quantity of cassava flour. The cyanide probably altering appreciably the alkalinity of the cement environment with consequent acceleration of the initial setting time. However, this condition appears to cease as cyanide becomes exhausted and the retarding action of the carbohydrate restored, hence, the final setting time remains unaffected.

There appears to be an optimum dosage level of cassava flour as a set-retarding admixture. The observed delay in the setting time of cement achieved by the addition of up to 3% cassava flour is within the requirements by the relevant British Standard [1, 22]. Furthermore, acceleration of the initial setting time occurs when the dosage level of cassava flour exceeds 3%, hence, 3% cassava flour by weight of cement appears to be the optimum dosage level of the admixture.

Table 2: Effects of Cassava Flour on the Setting Time of Cement

Cassava Flour Dosage Level	Initial Setting Time		Final Setting Time	
(%)	Hrs.	Min.	Hrs.	Min.
0	02	15	03	30
1	04	10	05	40
2	06	40	08	50
3	07	00	09	10
5	02	10	11	30
7	01	00	13	20
10	00	50	-	-

3.2 Workability

The effect of cassava flour on the workability of fresh concrete is shown in Figure 1 for different dosage levels of the admixture. The results indicate that the presence of cassava flour in concrete leads to better workability of the mix. The observed improvement in workability with increase in the dosage level of admixture is indicated by all two test methods used (slump and compacting factor). The improvement in workability indicate the presence of surface-active agents in cassava flour which are absorbed on the cement particles giving them a negative charge, and leads to repulsion between the particles with resultant dispersion and greater particle mobility [23]. The degree of improvement of workability of concrete by cassava flour admixture is appreciable, typically raising the slump and compacting factor from 5 mm and 0.79 to 40 mm and 0.89 respectively for 3% admixture dosage level.

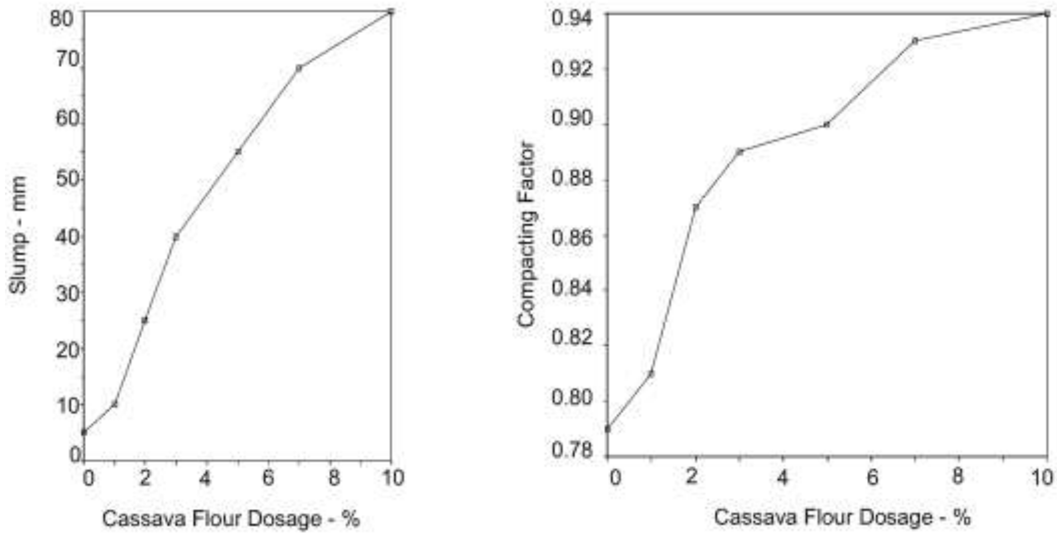


Figure 1: Effect of Cassava Flour Upon Slump and Compacting Factor

It was also observed that the addition of cassava flour in concrete markedly increased the cohesion and plasticity of the mix giving the concrete a better surface finish. This observation was confirmed during the compacting factor tests, as concretes with admixture dosage levels of 3% and above tend to stick in the hoppers and had to be eased by poking with a steel rod.

3.3 Saturated Density

The saturated density results for all mixes at different ages are presented in Table 3. The results generally showed small increases in saturated density (up to about 24 kg/m^3) with increasing time of storage in water from 3 days to 56 days. Table 2 also indicates that for a given cassava flour dosage level and age, the saturated density of the test concretes are higher than those of the control concrete. The trend of the result may be attributed to the enhanced workability achieved by the addition of cassava flour which permitted higher degree of compaction to be attained with the resulting increase in density. Another factor which may have contributed to the enhanced density of the test concrete may include the effect of the delayed setting resulting to the formation of denser gel [24].

Table 3: Density Test Results

Cassava Flour Dosage Level, (%)	Saturated density (kg/m^3) at				
	3 days	7 days	14 days	28 days	56 days
0	2529	2531	2530	2537	2542

1	2536	2532	2548	2554	2558
2	2550	2552	2559	2561	2574
3	2565	2563	2566	2568	2573
5	2558	2555	2561	2563	2665
7	2552	2556	2557	2560	2562
10	2554	2556	2560	2571	2574

3.4 Compressive Strength

Results for the development of compressive strength up to an age of 56 days for all mixes are shown in Figure 2. It is observed from these results that the trend of compressive strength development with age for concrete containing cassava flour admixture is similar to that obtained for the control concrete. In all cases, the compressive strength continues to increase with age and that, for concretes containing cassava flour in excess of 3% dosage level, the strength remain much lower than the control concrete at all ages. The lower strength is attributed to the prolonged retarding action of cassava flour due to the high dosage level of the admixture. These high dosage levels of cassava flour admixture are detrimental to the strength of concrete as no recordable strength is developed after 3 days and 7 days of age by concretes containing 7% and 10% dosage level of the admixture respectively.

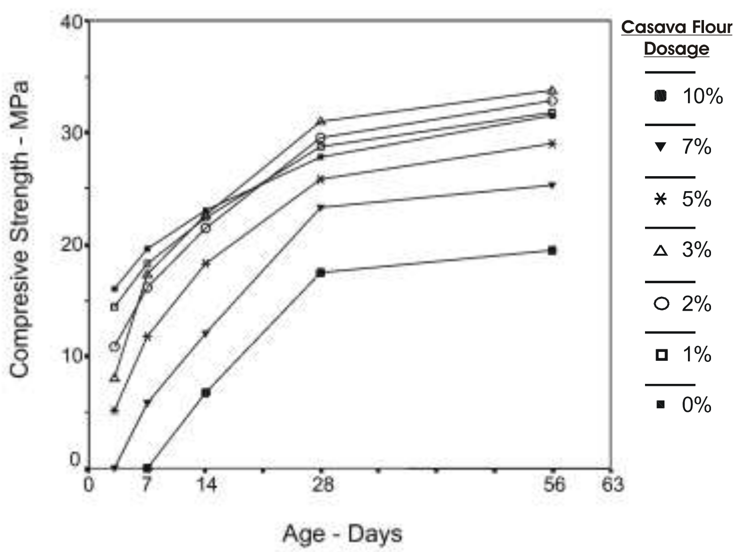
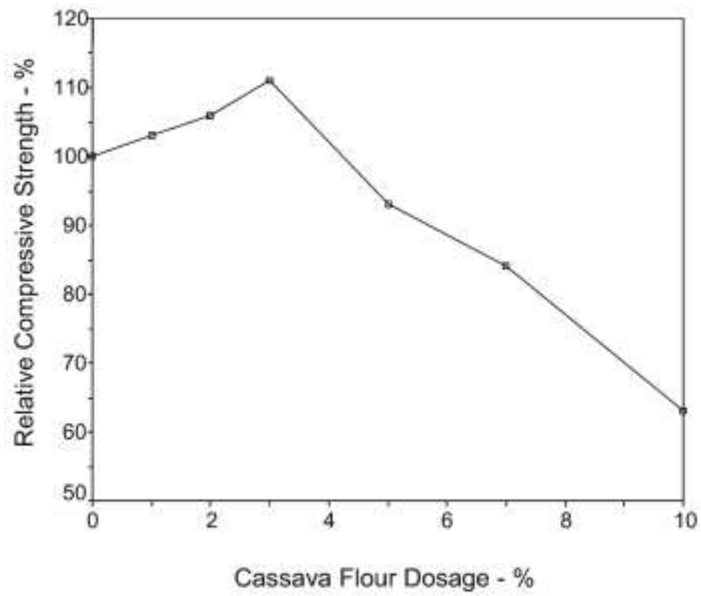


Figure 2: Relationship Between Compressive Strength and Age

However, the compressive strength of concretes with admixture dosage level of 1% to 3% are observed to be much closer to the control concrete, reduction in strength of these concretes being only at the early ages. A closer examination of Figure 2 further shows that concretes with admixture dosage of 1% to 3% developed higher strengths than the control concrete after about 14 days. The higher strength exhibited by the concretes at these ages suggests that the residual retarding effect of cassava flour is less significant after about 14 days, and strength development at this age is governed by other factors. The major factor contributing to the higher strength development is the enhanced workability and improved degree of compaction achieved by the addition of cassava flour in concrete. Other factors may include the effect of dispersion of cement particles and the formation of denser gel due to delayed setting [23, 24], as also may be observed from the density test results.



igure 3: Effect of Cassava Flour Upon Relative Compressive Strength.

Figure 3 shows the effect of cassava flour dosage level upon the relative compressive strengths of various test concretes, expressed as a percentage of the strength of control concrete at test age of 28 days. The results show that the relative compressive strength of concrete increases with increase in dosage level of cassava flour up to 3%. As the admixture dosage level exceeds 3%, there is a markedly decrease in the relative compressive strength of concrete due to the prolonged retarding action of cassava flour high dosage levels. The observed increase in the relative compressive strength is of the order of 11% at 3% dosage level of the admixture. It is again evident from Figure 3 that the optimum dosage level of cassava flour as a set-retarder is 3% by weight of cement.

4.0 CONCLUSIONS

The flowing main conclusions are drawn from the study:

(1) Cassava flour delays the setting time of cement by up to 6 hours at dosage level not exceeding 3% by weight of cement.

(2) Enhanced workability, compaction and higher density are achieved by the use of cassava flour as admixture in concrete.

(3) Cassava flour exhibits plasticizing effect in concrete and can be used to

advantage associated with plasticizing admixtures.

(4) Higher long-term compressive strength can be achieved in concrete by the use of cassava flour as admixture.

(5) The optimum dosage level of cassava flour as a set-retarding admixture is 3% by weight of cement.

(6) On the basis of this investigation, it would appear that cassava flour perform satisfactorily as a set-retarding admixture in concrete.

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