THE PERFORMANCE OF CASSAVA FLOUR AS A WATER-REDUCING ADMIXTURE FOR CONCRETE

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ABSTRACT

The performance of cassava flour as a water reducing admixture in concrete was investigated. Four concrete mixes of widely differing water/cement ratios were made and each of the mixes contained three different dosage levels of cassava flour as admixture. The properties tested include workability of the fresh concrete, saturated density and compressive strength of the hardened concrete. These properties were compared with those of similar concrete mixes made without admixture. It was observed that cassava flour has appreciable fluidifying action in the fresh concrete so that, under appropriate conditions, it either considerably improved the workability of the fresh concrete at normal water content or permitted a water reduction of at least 8% to be made while maintaining a given workability. Results of the tests also show that the 28 day compressive strength of concretes containing cassava flour admixture is higher than those of control concretes and that the compressive strength values obtained at 28 days exceeded those to be expected from water reduction alone.

Keywords: Admixture; Cassava Flour; Concrete; Workability; Compressive Strength.

INTRODUCTION

Water reducing admixtures are chemical additives for concrete. These admixtures are based on compounds of lignosulphates, hydroxyl-carboxylic acid salts and processed carbohydrates. They have been in use as water reducing admixtures in concrete for many years and their performance is covered in the Part 1 of the British Standard [1]

The performance of water reducing admixtures in concrete has been investigated by many researchers [2 – 9] and has been found to offer several advantages in concrete. They enable either a higher workability to be obtained at normal water content or a considerable reduction in the water content to be made while maintaining normal workability so as to produce hardened concrete with improved strength and durability.

In a pilot investigation on the potentials of cassava flour as a set-retarding admixture in concrete [10], it was observed that cassava flour exhibited plasticizing effect in concrete. To further enhance the ample use of cassava flour as admixture in concrete, the plasticizing effect of cassava flour in concrete is investigated with the purpose of utilizing it to achieve the advantages associated with water reducing admixtures. Hence, the present paper discusses the results of an investigation on the performance of cassava flour as a water reducing admixture in concrete.

MATERIALS AND PROCEDURES

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 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 used in this study can be found elsewhere [10].

Cement

The cement used in the investigation is ordinary Portland cement manufactured by Dangote (Nig.) Ltd and has been successfully used before, for testing the potentials of cassava flour as admixture in concrete [10].

Aggregates

The grading of the river sand used in the tests conformed to the zone 3 requirements of the British Standard, BS 882 [11]. The coarse aggregate used is natural gravel with particle size distribution shown in Table 1. The sieve analysis was carried out in accordance with the British Standard, BS 812 [12].

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

PREPARATION OF SPECIMENS

The mix proportion used was 1:2:4 by weight of cement, fine and coarse aggregate. Free water/cement ratios of 0.45, 0.50, 0.60 and 0.70 were adopted and for each water/cement ratio, concrete mixes were prepared with admixture dosage of 1.0%, 2.0% and 3.0% by weight of cement (3% dosage level was previously determined to be the optimum level of addition [10]). For comparisons of properties of the various concretes, control concretes without admixture were also made for each water/cement ratio.

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 aggregates and then water.

Workability measurements were carried out on the various concretes by two of three British Standard test methods (slump and compacting factor), BS 1881 [13]).

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 properties of the hardened concrete tested were the saturated density and compressive strength on 100 mm cubes, three samples being tested at each age of 7 days, 14 days, 28 days and 56 days.

RESULTS AND DISCUSSIONS

Workability

The effect of water/cement ratio on the workability of fresh concrete is shown in figure 1 for different dosage levels of cassava flour. For all concretes, the general trend of the results was for the workability to increase with increase in water/cement ratio. The improvement in workability with increase in water/cement is indicated by all two test methods used (slump and compacting factor). At a given water/cement ratio, the workability values for slump and compacting factor show that cassava flour exhibited appreciable fluidifying action and markedly improve the different workability values compared with those for the control concrete. This improvement in workability increases with increase in dosage level of the admixture. The improvement in workability indicates 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 particles with resultant dispersion and greater particle mobility [14].

In figure 1, the plotted values of slump and compacting factor derived from each particular mix with the same admixture dosage level are simply connected by straight lines. The curves show a rather regular increase with increase in water/cement ratio. For the particular concrete composition and admixture dosage used, these results for slump and compacting factor indicate that cassava flour is capable of effecting a water reduction of at least 8% relative to the control concrete for nominally equal workability. The water-reducing property of cassava flour is therefore accompanied by set-retardation as determined in a previous investigation [10] and may be classified as Type D admixture in accordance with the American Standard classification [15].

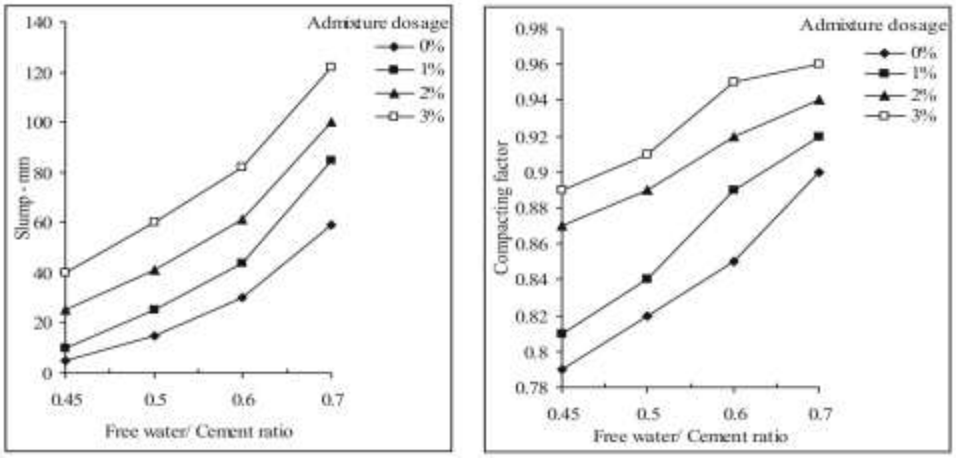


Figure 1: Effect of Water/cement Ratio Upon Slump and Compacting Factor

Saturated Density

The saturated density results for all mixes at different ages are shown in Table 2. The results generally showed small increases in saturated density with increasing time of storage in water from 7 days to 56 days. Table 2 also indicates that for a given water/cement ratio and age, the saturated density of concrete increases with increase in dosage level of the admixture, except for the mixes made with water/cement ratio of 0.70. The reduced density recorded with the mixes made with water/cement ratio of 0.70 may be attributed to the bleeding and segregation observed in these mixes. However, the observed general increase in saturated density with increase in admixture dosage level is attributed to the enhance workability achieved by the addition of cassava flour which permitted high degree of compaction to be attained with the resulting increase in density.

Table 2: Saturated Density Results

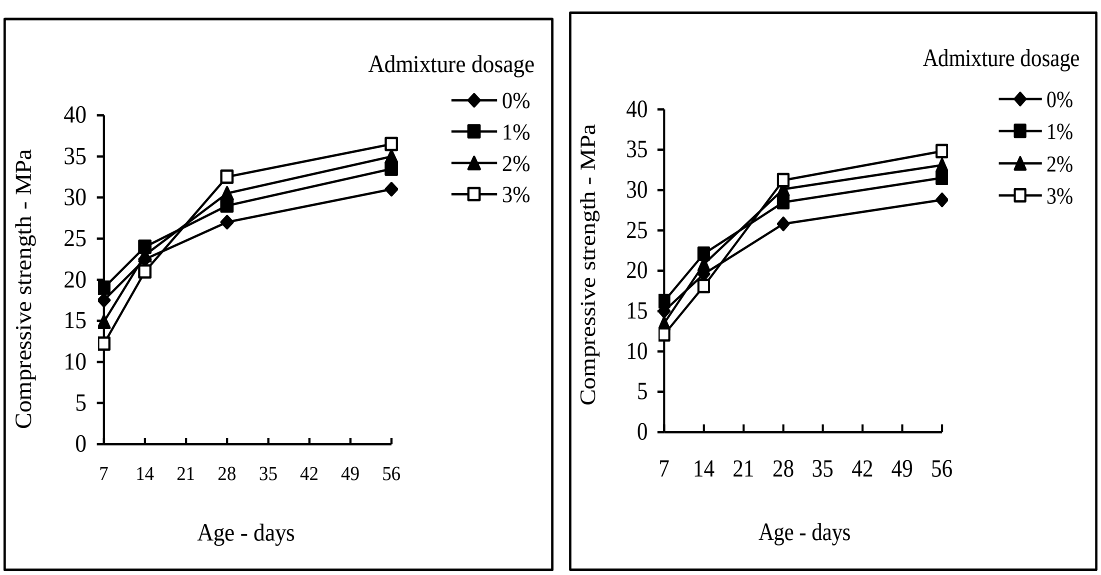
Water/cement ratio	Cassava flour dosage, (%)	Saturated density, (kg/m^3) at different ages			
		7 days	14 days	28 days	56 days
0.45	0	2531	2530	2537	2542
	1	2532	2548	2554	2558
	2	2552	2559	2561	2574
	3	2563	2566	2568	2573
0.50	0	2536	2532	2540	2545
	1	2540	2551	2558	2563
	2	2554	2561	2563	2568
	3	2560	2560	2565	2563
0.60	0	2533	2537	2542	2545
	1	2538	2549	2560	2565
	2	2556	2563	2563	2566
	3	2564	2566	2565	2568
0.70	0	2520	2526	2530	2535
	1	2529	2528	2536	2540
	2	2528	2536	2541	2538
	3	2524	2529	2532	2534

Compressive Strength

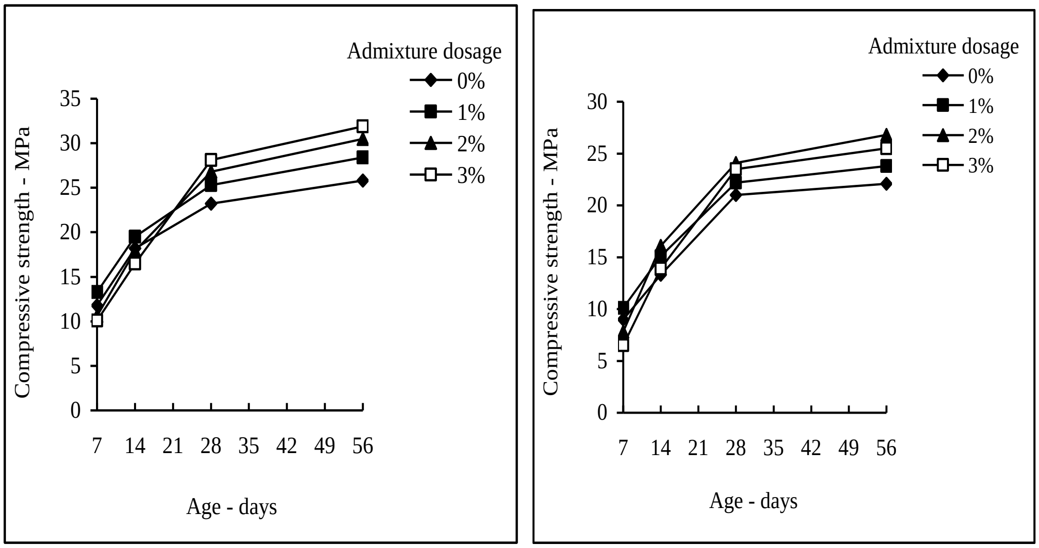
Results for the development of compressive strength up to the age of 56 days for all mixes are shown in figure 2. It is observed from the results that the trend of compressive strength development with age for concrete containing cassava flour admixture is similar to that obtained for the control concrete. In all cases, the compressive strength continues to increase with age and for concretes containing cassava flour admixture the strength is lower than the control concretes up to the age of about 14 days. The lower strength of these concretes at the early ages is attributed to the prolonged retarding action of cassava flour which becomes less significant after about 14 days [10], with consequent higher strength development thereafter than the control concretes. The higher strength exhibited by the concretes containing admixture after the age of about 14 days is attributed to the enhanced workability and improved degree of compaction achieved by the addition of cassava flour in concrete. The enhanced strength development may also be as a result of the effect of dispersion of cement particles and the formation of denser gel due to delayed setting [14, 16], as also may be observed from the density test results.

A closer observation of figure 2 further shows that at water/cement ratio of 0.70, the trend of the compressive strength results shown in figure 2d is similar to those of figures 2a, 2b and 2c except that at admixture dosage of 3% the compressive strength of this mix at all ages is lower than those of the corresponding mix with admixture dosage of 2.0%. This later trend may be attributed to bleeding and segregation observed with this mix which reduced the degree of compaction with consequent decrease in compressive strength.

Figure 3 shows the effect of water/cement ratio upon the relative compressive strength of various test concretes, expressed as a percentage of the strength of control concrete with free water/cement ratio of 0.70 at test age of 28 days.



(a) Free water/ Cement ratio = 0.46 (b) Free water/ Cement ratio = 0.50



(c) Free water/ Cement ratio = 0.60

(d) Free water/ Cement ratio = 0.70

Figure 2: Relationship Between Compressive Strength and Age.

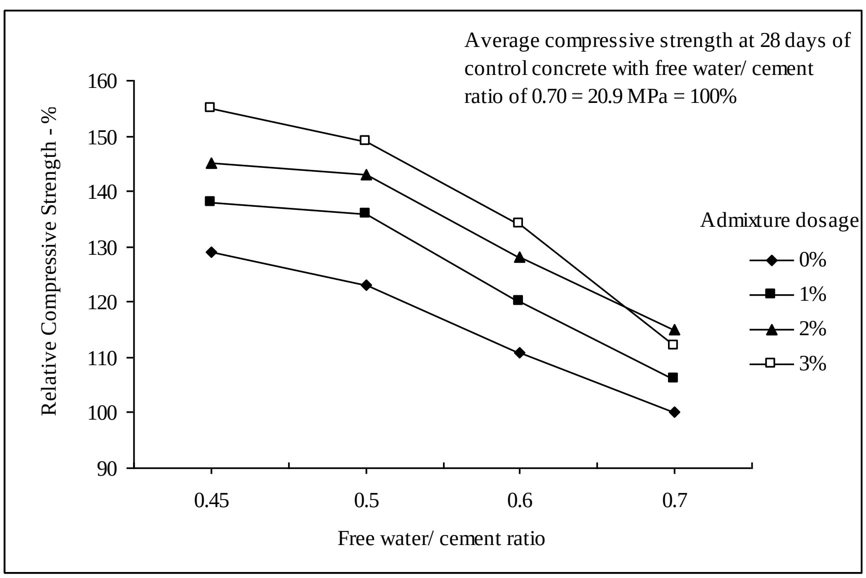


Figure 3: Effect of Water/cement Ratio upon Relative Compressive Strength at 28 Days.

The results show that the relative compressive strength of concretes without admixture at water/cement ratios of 0.60, 0.50 and 0.45 (equivalent to water reductions of 14%, 28% and 34% respectively relative to the control concrete with water/cement ratio of 0.70) are 111%, 123% and 129% respectively. For concretes containing cassava flour admixture, the relative compressive strengths are in the range 120% to 134% with a 14% water reduction, 136% to 149% with 28% water reduction and 138% to 155% with 34% water reduction. These strength values are appreciably greater than those derived from water reduction alone, particularly at the lower water/cement ratios, indicating that the observed advantages of cassava flour admixture increases as the water/cement ratio decreases.

CONCLUSIONS

For the particular concrete composition examined in this study, the following conclusions are drawn:

(1) Cassava flour is capable of considerably improving the workability of fresh concrete.

(2) Better compaction and higher density is achieved by the use of cassava flour as admixture in concrete.

(3) With the use of cassava flour as admixture in concrete, it is possible to achieve a water reduction of at least 8% relative to concrete without admixture for nominally equal workability.

(4) Cassava flour is classified as type D admixture in concrete.

(5) The 28 days compressive strength of concretes containing cassava flour admixture is higher than those of control concretes.

(6) For water-reduced cassava flour admixture concretes, the compressive strength values obtained at 28 days exceeded those to be expected from water reduction alone.

(7) On the basis of this investigation, it would appear that cassava flour perform satisfactorily as a water reducing admixture in concrete.

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