MINIMISING HOT WEATHER EFFECTS ON FRESH AND HARDENED CONCRETE BY USE OF CASSAVA POWDER AS ADMIXTURE

George Rowland Otoko

Civil Engineering Dept,
Rivers State University of Science & Technology, PH.

Abstract

Hot weather increases the temperature of fresh concrete causing increased concrete water demand, accelerated concrete shrink loss, increased rate of setting leading to placing and finishing difficulties, increased tendency for plastic shrinkage cracking, increased concrete temperature resulting in lower ultimate strength and increased potential for thermal cracking.

This paper presents possible implementation of hot weather concreting practices that minimize or eliminate fresh and hardened concrete problems by use of cassava powder admixture produced as expel milk water from pressing cassava slurry in "garri" production; which would otherwise pose environmental pollution problem. Thus, provides a low cost by - product, which can be widely used in the construction industry. It is concluded that a small quantity of cassava powder (0.05% of the weight of cement has the potential of increasing the workability and the early as well as the long term strength of concrete.

Keywords: Cassava powder; expel milk; "garri" production; low cost by - product; workability; strength of concrete

Introduction

Hot weather can be defined as any combination of high air temperature, how relative humidity, wind velocity and solar radiation tending to impair the quality of fresh or hardened concrete (ACI Committee 305, 1991). The most favorable fresh concrete temperature is between 50 °and 60 °F (Steven et al 1981, Sidney et al 1981). Yet hot weather temperature in excess of 100 °F exists during hot weather concreting. Usually, specifications only require the concrete temperature during placement to be less than 85 °or 90 °F, making it necessary to identify when hot weather conditions exist in order to implement precautionary hot - weather concreting practices.

Effects of temperature on the strength of concrete has been presented by price (1951), Bornes et al 1977, Dodson and Rajapopalan 1979, Klieger 1958, and Verbeck and Helmuth 1968, Zawde 1983, Otoko and Chinwah 1991. These studies show that high temperature affects the magnitude of evaporation from the surface of fresh concrete (William 1957) and evaporation has a pronounced effect on fresh concrete (Dan 1966), as more mix water is needed to maintain a given slump (fig 1 - after Kim 1992).

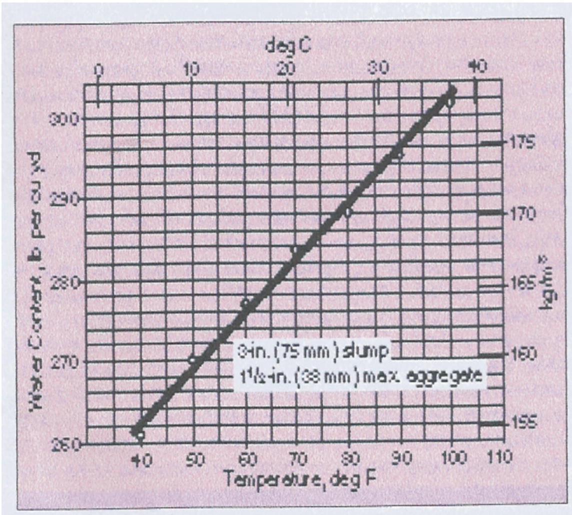


Figure 1. To maintain slump, water demand increases with all increase in concrete temperature (after Kim 1992)

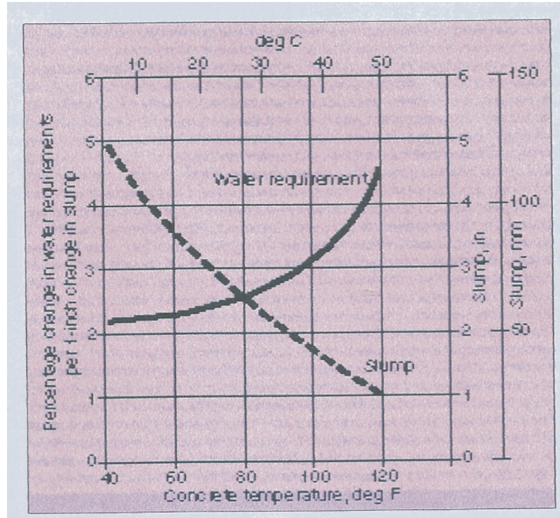


Figure 2. For every 20-degree increase in concrete temperature, initial slump decreases by 1 inch (after Kim 1992)

But adding water without adding cement increases the water cement ratio which in turn, lowers concrete strength and durability. The loss of slump decreases workability which can create serious transportation, placement and finishing problems (fig 2 - after Kim 1992). Adding water to increase the initial slump to compensate for the expected slump loss won't necessarily help because a higher initial slump will result in a higher slump loss (Robert 1977) as the rate of slump and the rate of hardening increases and thus setting time is reduced
(fig 3 - after Kim 1992).

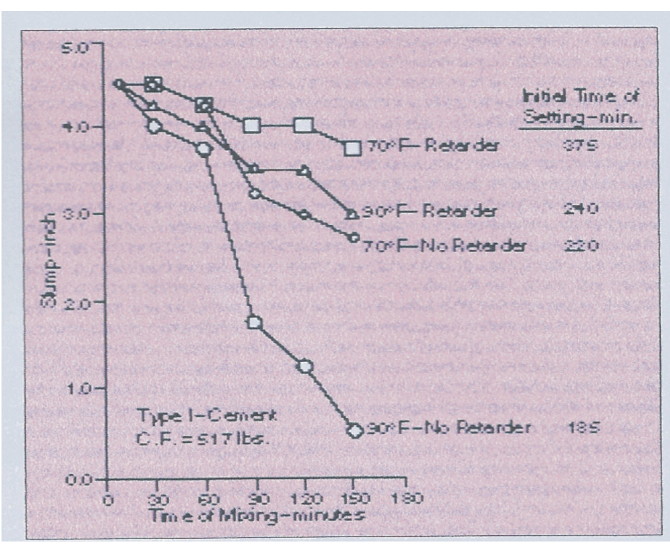


Figure 3. With an increase in concrete temperature, the rate of slump loss increases while the set time decreases (after Kim 1992)

One way of minimizing hot - weather problems with fresh concrete is to control the temperature of the fresh concrete and use chemical admixtures. Lowering the temperature of concrete slows slump loss, decreases water demand and increases setting time. In addition, chemical admixture can help offset the adverse effects of hot weather (Vance 1990, Otoko and Chinwah 1991). This does not alter the composition of hydration products (Lea 1988; Neville 2006). Retarding admixtures such as sugar, carbohydrate derivatives and some salts have been successfully used (Young 1972, Otoko and Chinwah 1991, Ramachandran 1993; Shetty 2004; Jumadurdiyer et al 2005).

Nigeria produced up to 34 million tonnes of cassava in 2002 (Philips et al 2004). Cassava is classified as complex sugar with molecular formula $(C_6H_{10}O_5)_n$ and a density of 1.5g/cm^3 (Frankhauser et al 1989) and is therefore selected for investigation as a possible retarding agent. Table 1 shows composition of cassava powder (after Leonel, et al 2009).

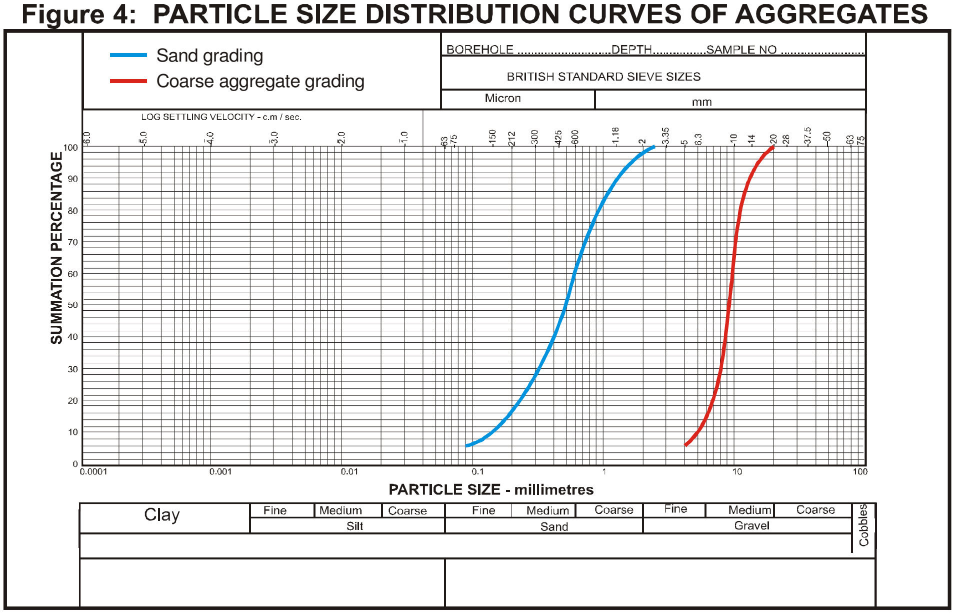
Table 1: Composition of cassava powder (after Leonel et al 2009)

Moisture	Starch	Fibre	Total Sugar	Lipid	Proteins	Ash
12.2%	88.43%	0.15%	0.14%	0.26%	0.07%	0.1%

Experimental Procedure

Concrete was generally made with ordinary Portland cement, fine aggregate which is natural river bed sand with specific gravity of 2.50 and maximum size passive sieve 2.66mm, coarse aggregate of crushed granite with specific gravity of 2.67 and size ranging from 5.0 - 19.0mm, and mixing water from the tap. The materials were batched by weight and mixed manually. The particle size distribution of the sand and coarse aggregate are given in fig 4.

Figure 4: PARTICLE SIZE DISTRIBUTION CURVES OF AGGREGATES



The aggregates were washed in order to get rid of organic and other deleterious materials which might react with the concrete constituents, thereby affecting the finished hardened concrete strength. A mix ratio of 1:2:4 and water cement ratio of 0.4 were chosen for all the 100mm concrete cubes casted.

Peeled cassava tubers grated into a slurry are put in bags and subjected to jacking pressure to expel water and the remnant used in producing "garri", a stable food in Nigeria. This waste milk water so extracted ordinarily pose serious environmental pollution problem, but is used in this study to produce cassava powder by allowing it settle for 24hrs, the clear water decanted, and the remnant is air dried and crushed into powder.

For phase I, concrete cube specimens were prepared, submerged in temperature bath, and maintained at the following curing temperatures: ambient, 40 ℃ and 60 ℃.

For phase II, a small quantity of sugar (0.05% and 0.15% of the weight of cement) was added to the fresh concrete as a known retarder; and the concrete cube specimen cured at ambient temperature.

For phase III, a small quantity of cassava powder (0.05% and 0.15% of the weight of cement) was added to the fresh concrete, to investigate its suitability as a controlled set retarder.

Compression tests were performed on the cubes using a universal hydraulic testing machine. All concrete cubes were tested for compressive strength after 3, 7, 14 and 28 days of curing.

RESULTS AND DISCUSSION

Phase I:

The objective of the Phase I tests, was to determine whether the early and later stages of strength development correlated with what is obtained in the litertaure.

Figure 5 shows the strength development of concrete with age at different temperature. from this figure, it is clear that the early stages of strength development agrees perfectly well with documented literature on the influence of temperature on the strength of concrete, since strength increased with increased temperature of moist-curing at 3 days. At 28 days the concrete cured at 60 ℃ dropped in strength considerably as would be

Table 1: Effect of temperature on concrete strength

S/NO	Temperature	Average Compressive strength N/mm^2			
		3 days	**7 days**	**14 days**	**28 days**
1.	Ambient	28.3	35.5	38.4	40.7
2.	48 ℃	29.6	38.9	41.8	43.4
3.	60 ℃	30.8	27.5	25.2	24.6

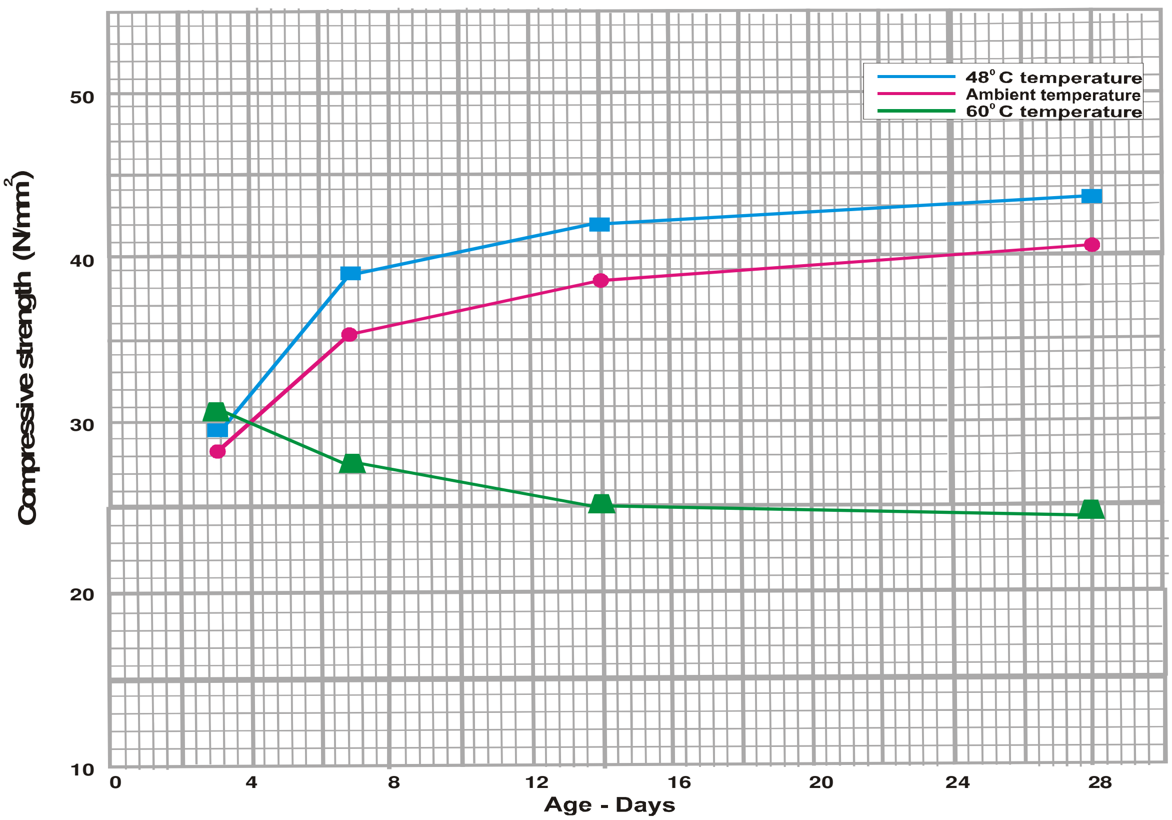


Figure 5: Effect of temperature on concrete strength

expected. Verbeck and Helmuth 1964 suggested that the reason for this is that the rapid initial rate of hydration at such a high temperature would retard the subsequent hydration and produces a non - uniform distribution of the products of hydration within the paste; since in such a case, there is not enough time available for the diffusion of the products of hydration away from the cement grain and for a uniform precipitation in the interstitial space (as is the case at lower temperature).

As a result, a high concentration of the products of hydration is built up in the vicinity of the hydrating grains, and this retards the subsequent hydration and adversely effects the long term strength. However, it is surprising that the concrete cured at 48 ℃ did not behave in a similar manner (Fig - 5) but instead gave a higher strength than the concrete cured at ambient temperature at 28 days. This behavior tends to agree with Shalon's tests (Shalon and Ravina 1960; Ravina and Shalon, 1971), which shows that under hot and dry conditions such as the condition under which the tests were carried out, strength decreases with an Increase in temperature down to a critical value at about 30 ℃, but between 30 ℃ and 45 ℃ there may be no further loss. This behavior has been observed using concrete without entrained air and stored at a relative humidity of between 20 and 70 percent (Neville 2006). It is possible that the presence or absence of entrained air is responsible, at least in part, for the difference between Kliegers result (Klieger 1958) and the present result. It seems then that all the factors involved in the problem are not yet fully understood, and careful site tests should be made before construction is begun in an unknown climate. In general terms, concrete in hot weather condition can be expected to have a lower strength than a similar mix cast in a cold weather condition, as mentioned previously - figure 5.

Phase II and III:

The object of the Phases II and III tests was to study the behavior of 'cassava powder' as a retarding agent against that of sugar which is a well known retarder (Lea 1970, Ashworth 1965). When sugar is used as a controlled set retarder, the early strength of concrete is severely reduced (Bloem 1959) but beyond about 7 days there is an increase in strength of several percent (Ashworth 1965). In the present work, this behavior was actually exhibited by sugar in more or less pronounced form, compared to the control mix (non-retarded mix) - see fig 6. But 'cassava powder' followed a completely different pattern of behavior. The concrete containing 'cassava powder' (0.15% of the weight of cement) considerably reduced both the early and later strength of the concrete (3-28 days); whereas, the concrete containing 'cassava powder' (0.05% of weight of cement) increased the early strength of concrete and beyond about 14 days, the strength is even more considerably increased of several percent compared with the control mix. This shows that even though this quantity of 'cassava powder' added to the concrete mix, retarded the setting time of the concrete, it does not at the same time have the side effect of reducing the early strength of the concrete as with sugar (0.5% and 0.15%) and cassava powder (0.15%) - see figure 6. It follows that a small quantity of cassava powder (0.05%) acts as a more acceptable retarder than sugar and probably than most other known retarders.

Table 2: Effect of cassava powder and sugar on concrete strength

S/NO	Test Specimen	Average Compressive strength N/mm^2			
		3 days	7 days	14 days	28 Days
1.	A - 0.05% sugar	23.1	30.9	31.8	38.4
2.	B - 0.05% - cassava powder	24.5	29.1	30.0	36.8
3.	C - 0.15% sugar	14.2	17.5	30.8	34.3
4.	D - control	22.0	25.3	27.6	28.7
5.	E - 0.15% cassava powder	20.1	21.4	22.7	23.5

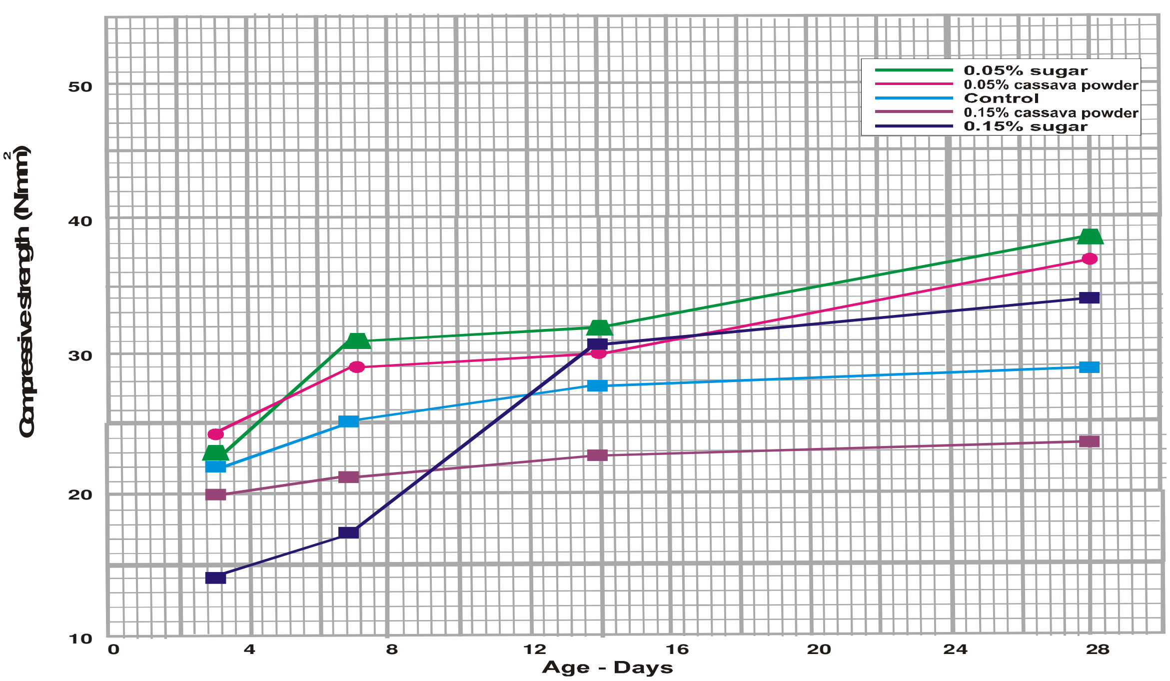


Figure 6: Effect of cassava powder and sugar on concrete strength

CONCLUSION

It is shown from literature that hot weather increases the temperature of fresh concrete causing it to demand more water to maintain a given slump, lose slump faster and set more quickly. This understanding can help contractors to implement hot weather concreting practices that minimize or eliminate fresh and hardened concrete problems. Cassava powder is considered as a low cost admixture to increase the workability and retard setting time of concrete.

Laboratory results show that the use of cassava powder as a retarder (0.05% of the weight of cement) has the potential of increasing workability, retarding setting time and at the same time increasing both the early and long term strength of the concrete. A quality not exhibited by any other known retarder. Its use is a simple, economically preferred solution to its environmental problem.

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