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THE EFFECT OF SUGAR CANE JUICE ON SETTING TIMES OF VARIOUS TYPES OF CEMENT PRODUCED IN NIGERIA.

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ABSTRACT

The objective of this research is to investigate the influence of Sugar Cane Juice (SCJ) on the setting times of various cement pastes. Sugar Cane Juice is incorporated with four different types of cement brands commonly found in Nigeria. The test results revealed that under normal curing conditions (Temperature=22^{0}C) and Relative Humidity = 60%), the efficiency of SCJ in retarding all four types of cement setting increases with increasing SCJ content. For three out of the four brands of cement, the initial setting times remained constant between 0 and 5%., After 5% SCJ content, the initial setting time increased as the SCJ content was increased. For the EAGLE cement brand, the initial setting and final setting times, remained constant between 0 and 3% SCJ content. The final setting times for the UNICEM, IBETO and EAGLE cement remained constant at between 0 and 5% SCJ content. Thereafter, the final setting time increased as the SCJ content increased. The final setting time for the DANGOTE cement experienced an increase immediately after the 0% SCJ content.

Key Words: sugar cane juice, setting time, cement paste.

INTRODUCTION

When cement is mixed with water, it sets and hardens gradually under normal climatic conditions. The hardening is caused by chemical reaction between the water and cement. In many parts of the world, a combination of high temperature, low relative humidity and hot wind that blows across the environment result in rapid evaporation of water from surface of fresh concrete. As a result, concrete sets earlier, leaving little or no time for concrete operation.

Fattui (1988), reported that when the temperature of cement mortar with a water/cement (w/c) ratio of 0.6 is increased from 27.8^{o}C to 34.5^{o}C, both initial and final setting times are nearly halved.

In order to provide proper setting time for concreting operation, especially when unavoidable delays between mixing and placing occur and to save concrete from other detrimental effects of adverse climatic conditions, cement set retardation or use of retarding admixtures is necessary Bazid and Bulent (2002). Admixtures are materials other than water, aggregates, hydraulic cement and any other reinforcement materials, used as an ingredient of concrete or mortar and added to a batch before or during concrete mixing. A retarding admixture/retarder is an admixture that retards the setting time of cement concrete, mortar or grout ASTM (1982).

Otunyo et al (2015), investigated the effect of sugar cane juice on slump values, setting times and compressive strength of concrete. They established that setting time was retarded as water was partially replaced by sugar cane juice. Slump values decreased as the content of the SCJ increased in the mix, while compressive strength decreased from 39.0 N/mm^2 at 0% SCJ:100% water to 13.08N/mm^2 at 10% SCJ: 10% water.

Bazid and Bulent (2002), also investigated the effect of pure sugar on setting time of various types of cement. The investigation concluded that setting time of cement was retarded by incorporation of sugar in cement under all conditions of curing. The extension in setting time was increasing with an increase in sugar content up to a certain limit (approximately 0.15%) and then started to drop with further increase in sugar content. Sugar accelerated the cement-setting when a higher sugar content (>0.3%) was used. Relatively low retarding tendency was shown by sugar under the second and third curing condition.

0.15% sugar-content acted as optimum sugar content for retarding the setting time.

Thomas and Birchal (1983), carried out an investigation on retarding action of sugars on cement hydration. They established that sugar interferes with the cement binding process in the concrete. A theory suggests that when concrete mixture contains sugar, the sugar molecules attach themselves to the hydrating cement and inhibit the chemical reactions involved in stiffening the material.

Another theory, called the “precipitation theory”, suggests that the addition of sugar increases the concentration of calcium, aluminium and iron in concrete. The sugar molecules combine with these metals to form insoluble chemical complexes that coat the cement grains. Several key chemical processes that harden the concrete are then impeded. Hydration slows down the process and concrete takes longer to set. For this reason, sugar is known as a retarder. Retarders normally increase the setting time of concrete.

It is important to note that all sugars do not retard cement hydration equally. Lactose, which is the sugar found in milk is a moderate retarder.

Furthermore, Bazid and Bulent (2002) observed that a retarding admixture causes cement to set retardation by the following mechanisms.

1) Adsorption of the retarding compound on the surface of cement particles, forming a protective skin, which slows down hydrolysis.
2) Adsorption of the retarding compound onto nuclei of calcium hydroxide, poisoning their growth, which is essential for continued hydration of cement after the end of induction period.
3) Formation of complexes with calcium ions in solution, increasing their solubility and discouraging the

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formation of the nuclei of calcium hydroxide.

4) Precipitation around cement particles of insoluble derivatives of the retarding compounds formed by reaction with highly alkaline aqueous solution, forming a protective skin.

Erdogan (1997) reported that retarding admixtures are mainly based on materials having ligsulfonic acids and their salts, hydroxyl-carboxylic acids and their salts, sugar and their derivatives and inorganic salts such as borates, phosphates, zinc and lead salts.

This study investigated the effect of sugar cane juice on the setting time of four types of cement commonly available in Nigeria, namely: EAGLE, DANGOTE, IBETO and UNICEM.

Sugar cane is abundantly available in Nigeria. Its use as a retarding admixture is of preferred economic advantage in the region when viewed against the importation of admixtures with very scarce foreign exchange. The economic empowerment of the local sugar cane cultivators is of great national importance.

MATERIALS AND METHOD

The brands of cement used are the DANGOTE, EAGLE, IBETO and UNICEM. The cement was visually inspected to ensure they were free of lumps. The physiochemical analysis of all four brands was carried out.

The sugar cane used for the study, were obtained from the fruit market in D/Line area of Port Harcourt. The original source of the sugar cane is Northern Nigeria. The sugar cane were cleaned, peeled, washed and cut into smaller pieces before the juice was extracted by putting the cut pieces into bags. The bags were then subjected to pressure by the use of four iron rods with fixed rebars to compress and extract the sugar cane juice.

The extracted SCJ was filtered in order to remove some residual particles of the sugar cane fibre. Water from the Civil Engineering Laboratoy of the Rivers State University of Science and Technology was used for the experiments. For each brand of cement, water was partially replaced with 3, 5, 10 and 15% of the SCJ. A control test with 0% SCJ was also carried out. Three tests for the initial and final setting times were carried out for the various content of the SCJ and the average values recorded. The water/cement ratio of 0.3 was adopted for the tests.

A purely arbitrary method of test was used to establish the setting times of the cements types. Utilizing what is known as the Vicat apparatus, the test is essentially a penetration test which measures the time required by a loaded needle with a 1mm square cross-section to penetrate into a standardized putty of neat cement and water. The setting times are expressed as the time which elapses from the instant when water is added until, for initial set, the needle fails to penetrate to the bottom of the test sample by about 5mm, and for final set it just fails to penetrate to a distance of 0.5mm from the surface of the test sample. Emesiobi (2000). Fineness and setting time tests were carried out on all the brands of the cement according to BS - EN 196-3 (1995).

RESULTS AND DISCUSSION

Table 1 shows the physiochemical analysis of all four brands of cement. These properties complied with the BS EN 197-1 (2011). Table 2 shows the physiochemical analysis of the unfermented sugar cane juice.

Table 1: Physiochemical analysis of cement brand

S/No.	Parameter	Eagle	Dangote	Ibeto	Unicem	Standard
1	Chloride (%)	0.064	0.059	0.0580	0.0600	0.10
2	Aluminium oxide (%)	3.960	3.600	2.8700	3.9100	6.00
3	Ferric Oxide (%)	3.080	2.850	2.8000	2.9800	6.00
4	Sulphurtrioxide (%)	2.040	2.790	2.8800	2.8000	<3.51
5	Insoluble Residue (%)	0.400	1.630	1.4500	0.3100	5.0 (max)
6	Sodium (%)	0.660	0.220	0.1700	0.1500	1.00
7	Loss on ignition (%)	2.210	1.700	1.6000	1.8800	5.0 (max)
8	Lime and Aluminium (%)	0.870	0.910	0.9500	0.8600	0.66 - 1.0
9	Silicon oxide (%)	21.750	20.900	22.4100	21.8000	20.0 (max)
10	Calcium oxide (%)	60.580	60.630	61.2000	60.5400	-
11	Tricalcium oxide (%)	58.060	67.010	63.0700	58.5000	-
12	Carbon dioxide (%)	1.500	1.450	1.4700	1.5000	-
13	Dicalcium Silicate (%)	18.400	9.370	16.6800	18.3700	-

Table 2: Physiochemical analysis of the sugar cane juice with NIS 235 ,(1987)

S/No.	Parameter	Result	standard
1	pH	5.67	>5
2	Specific Gravity	0.968	0.90-0.99
3	Sugar content (%)	15.1	-
4	Total Solid (mg/kg)	67.6	<83
5	Water Content (%)	20.44	<25
6	Sulphur (mg/kg)	0.08	1
7	Lead (mg/kg)	0.04	0.3
8	Copper (mg/kg)	0.02	0.5
9	Acidity (mg/koH/g)	0.7	1.5
10	Arsenic Acid (mg/kg)	<0.01	0.2
11	Salinity (ppm)	0.56	1
12	Conductivity (us/cm)	5.06	-
13	Iron (mg/kg)	2.8	5

Setting Times

The pH of SCJ 5.67 as observed from Table 2, which confirms that it is acidic in nature. 67.6% of its content is solids. Sugar content is 15.1% while water content is 20.44%.

From Figures 1-4, it can be deduced for three out of the four brands of cement, the initial setting times remained constant between 0-5% SCJ.. After 5% SCJ content, the initial setting time increased as the SCJ content was increased. For the EAGLE

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cement brand, the initial setting time remained constant between 0-3% SCJ content.

The final setting time for the UNICEM, IBETO and EAGLE cement remained constant at between 0-5% SCJ content. Thereafter, the final setting time increased as the SCJ content increased.

The final setting time for the DANGOTE cement experienced an increase immediately after the 0% SCJ content. This result from DANGOTE cement corroborated, Akogu (2011), who previously established that the setting time of concrete increased up to 0.05% sugar content in concrete.

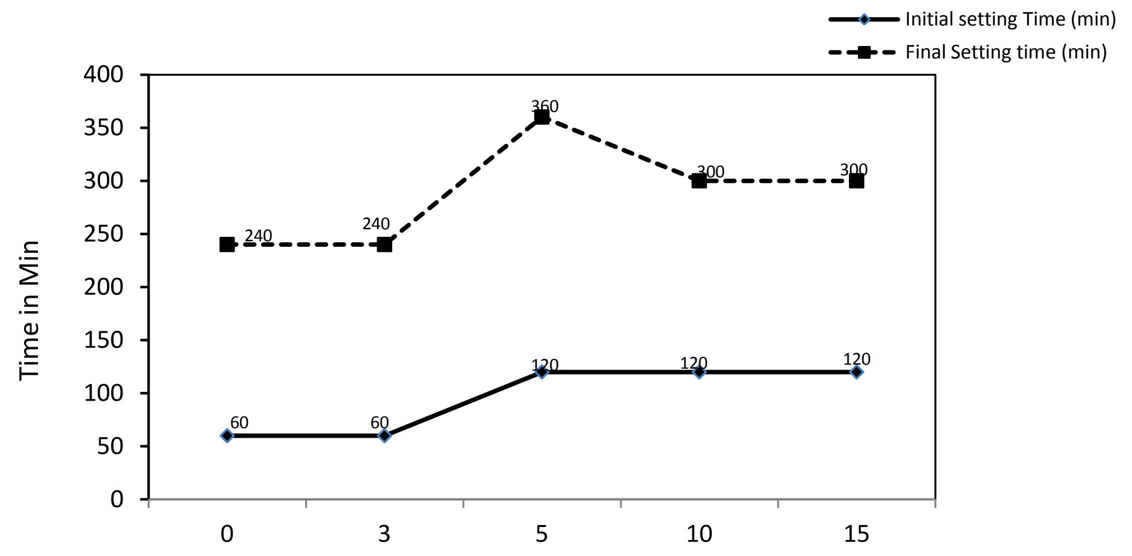

Fig. 1: Plot of SCJ % by weight of cement (EAGLE CEMENT)

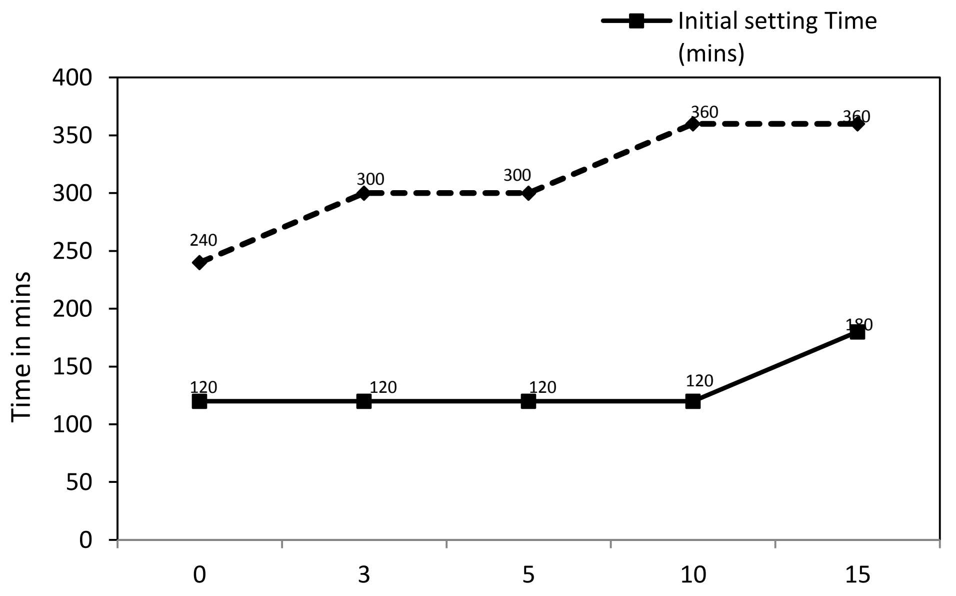

Fig. 2: SCJ by % weight of cement (DANGOTE CEMENT)

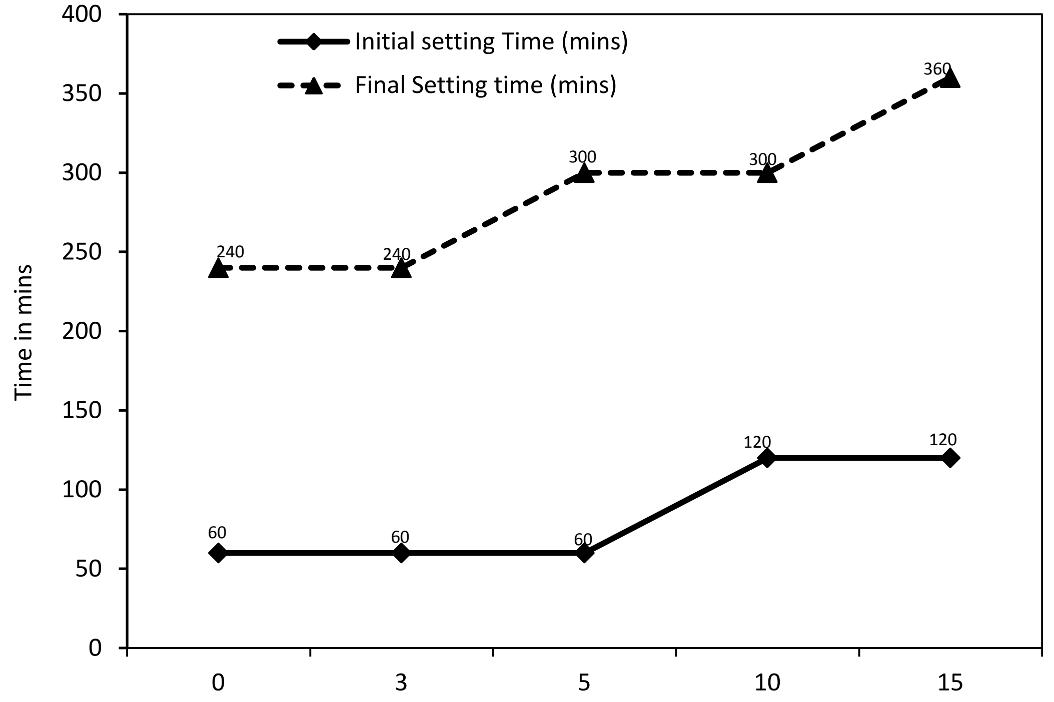

Fig. 3: SCJ % BY Weight of cement (IBETO)

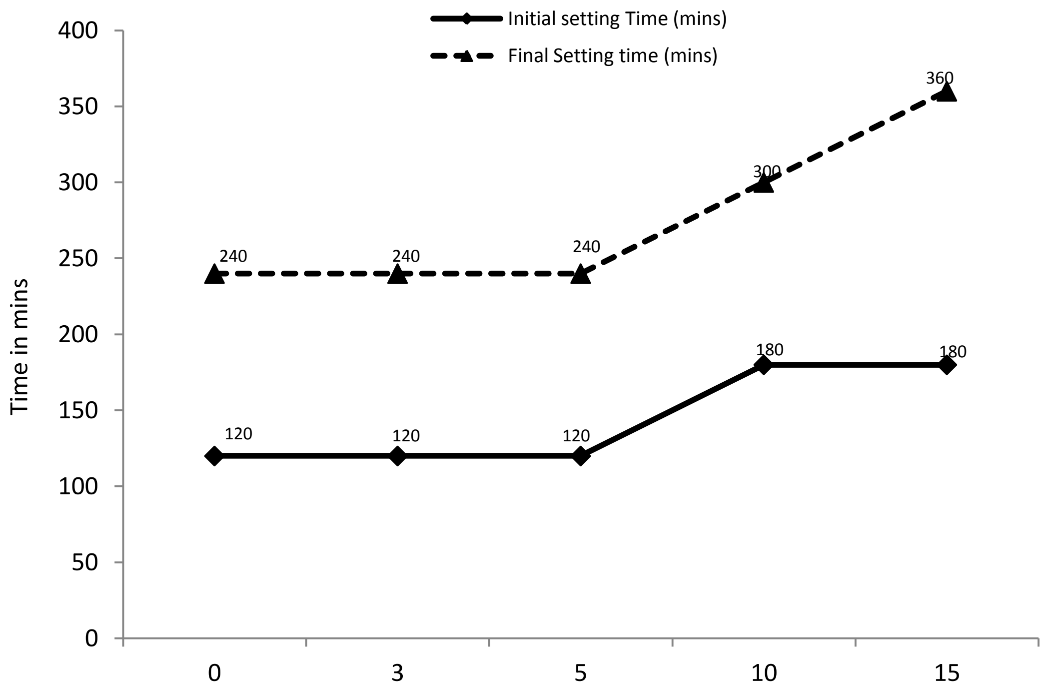

Fig. 4: SCJ % by weight of cement (UNICEM)

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Setting times for all four brands of cement produced in Nigeria was retarded by partial replacement of water with sugar cane juice. Since sugar cane juice is abundantly available in Nigeria, its use as a retarder is of economic advantage when applied to all cement brands produced in Nigeria.

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