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Effect Of Hydrochloric Acid On Cement-Sugar Cane Straw Ash Concrete

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--***ABSTRACT***--
Experimental study was conducted to investigate the acid resistance of concrete containing sugar cane straw ash (SCSA). SCSA was used to partially replace Portland cement by 0, 5, 10, 15 and 20% by weight of binder in order to prepare SCSA concrete. Water to binder ratio was 0.4 and Conplast SP 430 superplasticizer was added to improve workability. SCSA concrete was cured for 7 days and thereafter immersed in 10% hydrochloric acid solution for 28 days. The weight of the concrete cubes were determined before and after immersion in acid solution.Compressive strength tests were also carried out on the concrete cubes immersed in acid solution as well as the corresponding ones cured in water only. All the concrete cubes immersed in acid solution experienced loss in weight due to leaching with the 10% SCSA concrete recording the least percentage loss. The control concrete immersed in acid experienced the biggest percentage drop in compressive strength compared to the SCSA concretes. Thus, the incorporation of sugar cane straw ash of not more than 10% was able to improve the resistance of the concrete towards acid attack. It is recommended that SCSA can be incorporated into concrete to improve resistance to acid attack. Long term studies are also suggested.
***KEYWORDS**: concrete, hydrochloric acid, portland cement, sugar cane straw ash.*

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I. INTRODUCTION

Concrete was for a long time considered to be a very durable material requiring little or no maintenance. The assumption is true except when it is subjected to highly aggressive environments. Some concrete structures are built in highly polluted urban and industrial areas, aggressive marine environment, harmful sub-soil water in coastal areas and many other hostile conditions where other materials of construction are found to be non-durable (Shetty, 2009).

Concrete is not fully resistant to acids. Most acid solutions will slowly or rapidly disintegrate Portland cement concrete depending upon the type and concentration of acid. The most vulnerable part of the cement hydrate is $Ca(OH)_2$, but C-S-H gel can also be attacked.

Notable researchers have demonstrated the use of pozzolanic admixtures to improve the properties of concrete (Frias et al. 2007; Cizer et al. 2006; Ketkukah and Ndububa, 2006; Salau et al. 2012). Research findings have also shown the ability of pozzolanic materials to enhance the resistance of concrete to acid attack (Hussin et al. 2009).

The sugar cane production n Nigeria in 2016 was 1,337,572 tonnes. The sugar cane straw is a by-product of the sugar cane industry. It is converted into sugar cane straw ash (SCSA) by burning the sugar cane straws. According to Ahmed and Shaikh (1992) and Otoko (2014), the physical and chemical properties of sugar cane bagasse ash are found to be satisfactory and conform to the requirements of class N pozzolana (ASTM C 618-78). The major oxides in bagasse ash being Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, P_2O_5 and MnO and having loss on ignition less than than the specified value of 10% (Otoko, 2014).

The aim of this research work is to determine the effect of hydrochloric acid on cement-sugar cane straw ash concrete.

II. MATERIALS AND METHODS

Materials

Sugar cane straws were obtained from the local market in Osogbo, Nigeria. The straws were turned to ash by burning in drum with limited air entry. The resulting ashes were sieved using 600µm sieve. Dangote Portland cement was used and it was sourced in Iree, Nigeria. Fine aggregate was sourced from the drains in the compound of Osun State Polytechnic Iree, impurities were removed and the sand was sieved using 5mm size sieve. The coarse aggregate used was 10mm size and it was obtained from Igbajo, Nigeria. Conplast SP 430 superplasticizer was used. Concentrated Hydrochoric acid was also sourced from Osogbo in Nigeria.

Experimental Procedure

The concrete mix ratio adopted for this research work was cement:fineaggregate:coarse aggregate of 1:1.3:2.6. The water to binder ratio was 0.4 and 1% Conplast SP 430 was applied. Portland Cement was replaced by sugar cane straw ash at 0, 5, 10, 15 and 20% levels. The size of the concrete mould used was 100 x 100 x 100 mm. The casted concrete weredemoulded 24 hours after casting and cured in water for 7 days. The cubes were removed from water and weighed after curing and then immersed in 10% Hydrochloric Acid solution for 28 days. Thereafter, the cubes were removed from the acid solution and weighed again. The loss in weight and percent loss in weight of the concrete cubes were determined. After testing the concrete samples in acid solution, the samples were tested for compression to determine the residual strengths. Concrete samples that were continuously cured in water were also tested for compression and compared with the strengths of the corresponding samples immersed in acid.

III. RESULTS AND DISCUSSION

The results of the experimental programme on the concrete cubes are shown in Tables 1 and 2 as well as Figures 1, 2 and 3. The results revealed all the concrete cubes experienced loss in weight as a result of leaching resulting from the reaction of the hydrochloric acid with concrete. The percentage loss in weight was 2.12%, 2.11%, 1.98%, 2.50% and 3.31% for 0%, 5%, 10%, 15% and 20% replacement of cement with sugar cane straw ash (SCSA) respectively. This revealed that 5% and 10% SCSA replacement performed better than the control with 10% SCSA replacement being the best. Figures 4 and 5show the appearance of concrete cubes before and after immersion in hydrochloric acid. The loss in compressive strengths of 0, 5, 10, 15 and 20% SCSA concrete cubes immersed in 10% HCl solution were 62.9%, 38.3%, 31.3%, 37.2% and 30.2% respectively compared to the same concrete cubes cured in water. The control concrete cubes experienced the highest strength reduction ratio compared to SCSA concrete cubes. The abundant free lime of the control concrete cube makes it susceptible to acid attack. The SCSA concretes have better resistance towards acid attack because SCSA as a pozzolan reduces the amount of calcium hydroxide that is susceptible to acid attack(Hussin et al. 2009).

IV. CONCLUSION

The following conclusion can be drawn from this research work:

The incorporation of sugar cane straw ash of not more than 10% was able to improve the resistance of concrete towards acid attack.

The compressive strengths of the concrete cubes immersed in acid solution were lower than their corresponding concrete cubes cured in water only.

RECOMMENDATIONS

Incorporation of sugar cane straw ash in the right dosage will enhance the resistance of concrete products towards acid attack.Research into the use of sugar cane straw ash of higher degree of fineness should be investigated.

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Table 1: Loss in Weight on Immersion of Concrete Cubes in Hydrochloric Acid

Percentage SCSA (%)	Weight of Concrete Cubes before immersion in acid (g)	Weight of Concrete Cubes after immersion in acid (g)	Loss in Weight of Concrete Cubes (g)	Percentage loss in Weight of Concrete Cubes (%)
0	2404.5	2353.5	51.0	2.12
5	2442.6	2391.1	51.5	2.11
10	2357.7	2311.0	46.7	1.98
15	2325.3	2267.2	58.1	2.50
20	2155.2	2083.9	71.3	3.31

Table 2: Bulk Densities and Compressive Strengths of Concrete Cubes

Percentage SCSA (%)	Density of Concrete Cubes before immersion in acid (g/cm^3)	Density of Concrete Cubes after immersion in acid (g/cm^3)	Compressive Strength of Concrete Cubes immersed in water (N/mm^2))	Compressive Strength of Concrete Cubes immersed in acid (N/mm^2)
0	2.40	2.35	47.79	17.71
5	2.44	2.39	36.75	22.67
10	2.36	2.31	30.80	21.15
15	2.33	2.27	30.57	19.20
20	2.16	2.08	20.82	14.53

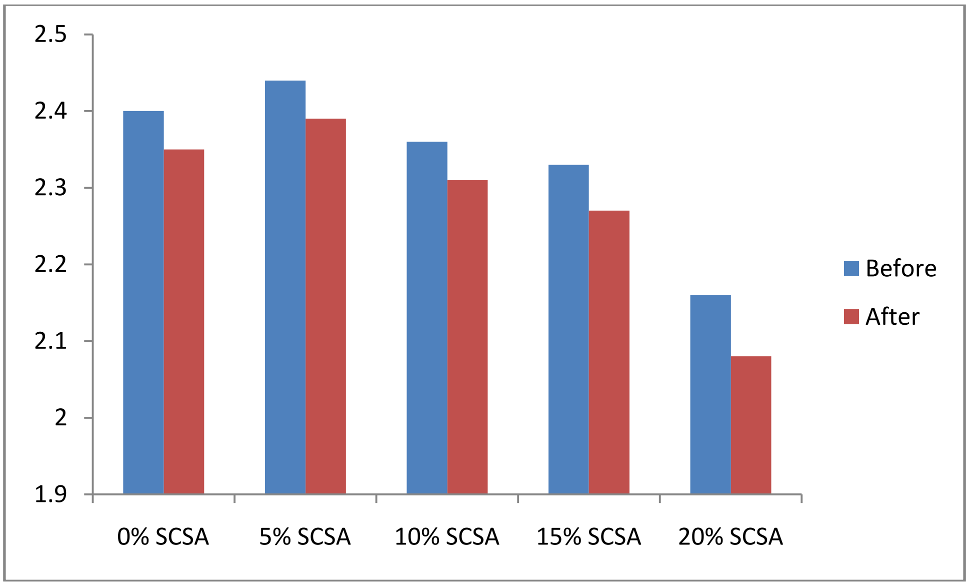

Figure1. Bulk Densities of Concrete Cubes Before and After Immersion in Acid solution in g/cm^3

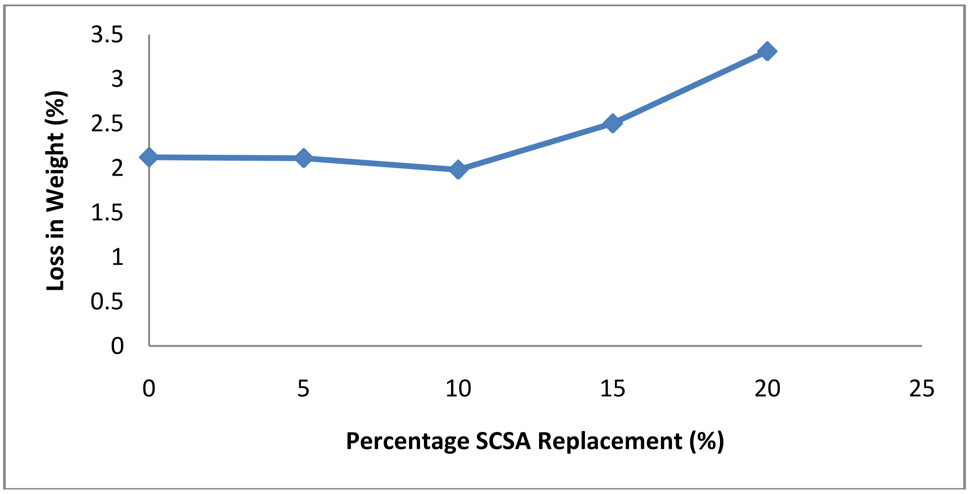

Figure 2. Results of Immersion of Concrete Cubes in Hydrochloric Acid

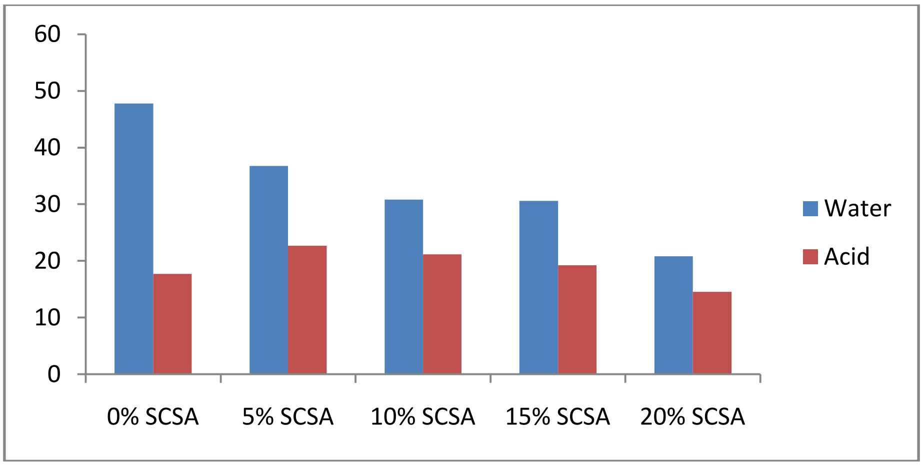

Figure 3. Comparative Compressive Strengths of Concrete Cubes immersed in water and acid in N/mm^2

Figure 4: Concrete Cubes Before Immersion in Acid

Figure 5: Concrete Cubes After Immersion in Acid

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