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Effect of Sugar Cane Bagasse Ash (SCBA) on Sulphate Resistance of Concrete

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Abstract: This paper presents the results of an experimental work that was carried out to determine the effect of sugar cane bagasse ash (SCBA) on the durability of concrete to sulphate attack when utilized as cement replacement material, the cement was replaced with 0 – 50% The sulphate resistance was assessed by measuring the weight loss and compressive strength loss. It was obtained that inclusion of SCBA in concrete regardless the replacement percentage significantly improved the resistance to sulphate ingress and reduced the weight loss and compressive strength loss, the minimum weight loss and strength loss obtained were 1.2% and 2.2% respectively at 15% SCBA.

Index Terms: Sugar Cane Bagasse Ash; Sulphate Resistance; Weight Loss; Compressive Strength Loss.

I. INTRODUCTION

Utilization of agricultural, industrial and agro-industrial by-products in concrete production has become an attractive option to the researchers over all the world. Utilization of such wastes as cement replacement materials can reduce the cost of concrete and also minimize the negative environmental effects associated with the disposal of these wastes. Silica fume, rice husk ash, fly ash, Metakaolin and ground granulated blast furnace slag are well established pozzolans because of high silica contents in their chemical composition. The calcium hydroxide (unfavorable product from the cement hydration) released during the hydration of Portland cement reacts with the silica content present in the pozzolans and water to form additional calcium silicate hydrate which is responsible for the compressive strength in concrete [1]. Bagasse is the waste produced after juice extraction in Sugar industry, which is usually used as a fuel for boilers in the sugar mills and alcohol factories which produce high amounts of ash annually. Previously the sugar cane bagasse was burnt as a means of solid waste disposal, with increasing of the cost of natural gas, electricity, and fuel oil and with calorific properties of these wastes; since last decade the bagasse has been used as the principal fuel in cogeneration plants to produce electric power [2], [3]. Sugar cane bagasse ash is recently accepted as a pozzolanic material, study of using bagasse ash as a pozzolanic material is not well-known and its uses are limited and most of bagasse ash is disposed in the landfills [4], and "only a few studies have been reported on the use of bagasse ash as a pozzolanic material in respect of the cement paste" [5].

Chusilp et al., 2009 investigated the effects of loss on ignition (LOI) (5, 10, 15 and 20%) of BA on the compressive strength and Sulphate resistance of the mortar. The Boiler BA with LOI 20% was further burnt under controlled temperature at 550 °C for 45 minutes which brought down the LOI to 5% and ground until the particles retained on No. 325 sieve were less than 5% of the weight. The w/b ratio varied in the range of 0.71 to 1.03 (increased with the increase of replacement level). They obtained that the compressive strength of mortars containing original bagasse ash OBA (LOI = 20% before grinding and burning) were very low compared to the control specimen at different replacement levels and at all ages, a decrease in the strength in the range of 15 – 69% was obtained at 28 days. Inclusion of ground BA can greatly improve the compressive strength of the mortar; an increase up to 26% over the control specimen was obtained at 10 – 20% ground bagasse ash replacement at 28 days. The high LOI of BA (greater than 10%) significantly lowered the compressive strength of mortar at the early age (7 days), however, the LOI content up to 20% slightly lowered the compressive strength of mortar at the later age (more than 28 days). Mortar bars made of 10 – 20% BA with LOI between 5% and 20%) showed little deterioration after being immersed in a 5% Magnesium Sulphate solution for 360 days, while those made of 30 – 40% BA with high LOI (greater than 10%) showed a severe deterioration [6].

A. Problem statement

There is a continuous increase in the sugar industry worldwide. Approximately 1800 Million tons of sugarcane are annually produced over the world which leave about 40-45% bagasse after juice extraction for sugar industry giving an average annual production of about 700 Million tons of bagasse as a waste material at minimum. Previously the sugar cane bagasse was burnt as a means of solid waste disposal; with increasing of the cost of natural gas, electricity, and fuel oil due to all these reasons together with the calorific properties of bagasse since last decade the bagasse has been used as the principal fuel in cogeneration plants to produce electric power. Sugar cane bagasse ash is an agro-industrial by-product and there are many environmental problems associated with its disposal for instance: landfill volumes, underground water pollution, global warming and methane emission which cause degradation of the Ozone layer. Although the SCBA it is a pozzolanic material but still it is disposed to the landfills every day.

B. Objectives of the study

The main objective of this research was to determine the effectiveness of sugar cane bagasse ash (SCBA) as a cement replacement material in concrete, the objective of the current study was to determine the effect of SCBA on concrete durability by investigating its effect on resistance to sodium sulphate ingress.

II. METHODOLOGY

Sulfate attack is one of the important chemical reactions that occur in concrete due to penetration of sulphate bearing compounds, most commonly sodium sulphate Na_2SO_4 and magnesium sulfate MgSO4. Sulfate attack is generally attributed to the formation of ettringite and gypsum which may cause cracking, spalling, mass loss and strength loss [7]. The change in compressive strength is one of the means that detect sulphate attack, if there is no reduction in the compressive strength this means that there has been no attack, and the assessment of the extent of damage by determining the change in compressive strength appears to be reliable [8]. In this study, the sulphate resistance of concrete was assessed by measuring weight loss and compressive strength loss. For that purpose 100 mm cubes were cast, demoulded after 24 hours and cured in water for 28 days, after then they were immersed in 5% sodium sulphate (Na_2SO_4) solution, after completion of a period of six months immersion, the compressive strength and weights of samples were measured and compared with those cured in tap water to calculate the weight loss and the compressive strength loss. The compression test was performed on 100 mm cubes and the compressive strength was determined on three cubes at 7, 28, 90 and 180 days of curing. In the compression test, the cube, which still wet, was placed with the cast faces in contact with the platens of the testing machine; the load on the cube was applied at a constant rate of 3.0 KN/s according to BS 1881: Part 111: 1983 [9]. Figure 1 shows the compression test procedure.

Figure 1: Compressive strength test procedure

III. RESULTS AND DISCUSSION

A. Effect of SCBA on Weight Change

The change in weight was determined by calculating the relative weight of the concrete sample's weight immersed in 5% sodium sulphate solution for six months divided by the weight of the same samples cured in tap water for six months as well. The normal concrete experienced a weight loss of about 6.8% due to ingress of sulphate ion in the concrete. The relative weights and weight losses of the SCBA mixes are presented in Figure 2 and Table 1. 5%SCBA and 10%SCBA brought down the weight loss from 6.8% for NC to 2%. The weight loss for 15%SCBA was 1.2% whereas the weight loss increased at 20%SCBA to about 2.3% and kept on increasing with the increase of the SCBA replacement percentage until it reached 3.8% at 35%SCBA. At 40%SCBA – 50%SCBA the weight losses were almost similar about 3.4% and they were slightly less than the weight loss in 35%SCBA.

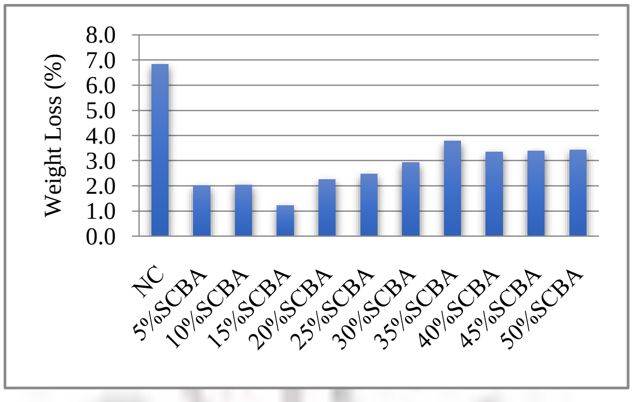

Figure 2: Change in weight of SCBA concrete

TABLE 1: CHANGE IN WEIGHT OF SCBA CONCRETE

Mix Code	Weight (N)		Relative Weight = *B/A*	Weight Loss (%)
	Tap Water (A)	5% Na_2SO_4 Solution (B)		
NC	24.9	23.20	0.932	6.8
5% SCBA	24.9	24.4	0.980	2.0
10% SCBA	24.6	24.1	0.980	2.0
15% SCBA	24.8	24.5	0.988	1.2
20% SCBA	24.4	23.9	0.977	2.3
25% SCBA	24.3	23.7	0.975	2.5
30% SCBA	24.0	23.3	0.971	2.9
35% SCBA	23.8	22.9	0.962	3.8
40% SCBA	23.9	23.1	0.967	3.3
45% SCBA	23.7	22.9	0.966	3.4
50% SCBA	23.3	22.5	0.966	3.4

B. Effect of SCBA on Change in Compressive Strength

The change in compressive strength was determined by measuring the compressive strength of concrete cubes after a period of six months immersion in 5%Na_2SO_4 solution compared to that of the concrete cured for six months in tap water. The strength loss was found to be about 8% for the normal concrete (NC). Figure 3 and Table 2 present the results of change in strength of SCBA concrete mixes due to sulphate attack. 5%SCBA experienced a strength loss of 2.7% this percentage decreased to 2.5% and 2.2% at 10%SCBA and 15%SCBA respectively. At 20%SCBA the strength loss slightly increased to 2.4% and kept on increasing until it reached 4.6% at 50%SCBA. The improvement that observed in sulphate resistance up to 20%SCBA was about three times compared to the normal concrete, similar findings were reported by [6].

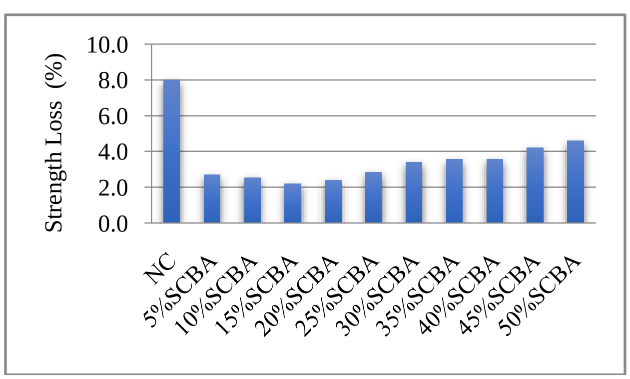

Figure 3: Change in compressive strength of SCBA concrete

TABLE 2: CHANGE IN COMPRESSIVE STRENGTH OF SCBA CONCRETE

Mix Code	Compressive Strength (MPa)		Relative Strength = *B/A*	Strength Loss (%)
	Tap Water (A)	5% Na_2SO_4 Solution (B)		
NC	69.01	63.50	0.920	8.0
5% SCBA	100.21	97.500	0.973	2.7
10% SCBA	99.75	97.21	0.975	2.5
15% SCBA	97.23	95.09	0.978	2.2
20% SCBA	85.80	83.74	0.976	2.4
25% SCBA	74.14	72.04	0.972	2.8
30% SCBA	70.36	67.96	0.966	3.4
35% SCBA	66.06	63.71	0.964	3.6
40% SCBA	63.78	61.50	0.964	3.6
45% SCBA	58.55	56.08	0.958	4.2
50% SCBA	53.15	50.71	0.954	4.6

IV. CONCLUSION

From this experimental study it can be concluded that: Inclusion of SCBA in concrete regardless the replacement level significantly improved the sulphate resistance of concrete by reducing the weight loss and strength loss due to sulphate attack. The minimum weight loss and strength loss obtained were 1.2% and 2.2% respectively at 15%SCBA. The improvement in sulphate resistance can be attributed to the consumption of portlandite in the pozzolanic reaction which prevented the formation of gypsum.

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