"TO CHECK THE POZZOLANIC REACTIVITY OF SUGARCANE BAGASSE ASH AS A PARTIAL REPLACEMENT MATERIAL FOR CEMENT"

Mr. Ranjeetsinh S. Patil[1], Mr.V.G.Sawant[2]
[1] Assistant Professor, [2] Assistant Professor,
Department of Civil Engineering ,Padmabhooshan Vasantraodada Patil Institute of Technology, Budhagaon,Sangli, India.

Abstract : Now days more and more industries are growing and raw material is converted into final usable product. In this process the industrial waste products are increasing. Before making use of these waste products for construction purpose it is necessary to find out, weather these products will help to reduce the environmental pollution and reduces cost of construction. Sugar Cane Bagasse Ash (SCBA) is one of the major waste products obtained from sugar industries. To find out the use of this waste ash in concrete or in mortar, it is necessary to check the reactivity of SCBA. In this experimental study the reactivity of SCBA for different grinding levels and calcinations levels is checked so as to arrive at the optimum grinding level & calcination temperature. This in turn would generate maximum reactivity of SCBA, which is usable with the help of modified Chappelle method. In this study it is seen that, after performing grinding for 120 minutes and calcination at 6000C for 90 minutes, the pozzolanic reactivity increases for the samples used as received from industry.

IndexTerms - Sugarcane Bagasse Ash, Pozzolanic Reactivity, Grinding and Calcination.

I. Introduction

The industrial by products, which have been disposed earlier, are now being considered for beneficial use. This beneficial use can reduce our nation's carbon production and consumption of new materials, which results into economic gains. A good solution to the problem of recycling these waste products is by burning them in a proper and controlled environment and the produced ash can used as a construction material. Ordinary Portland Cement Is recognized as the major construction material throughout the world. Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials. In addition to these, agricultural wastes such as rice husk ash and wheat straw ash are also being used as Pozzolanic materials. The SCBA is one of the major crops grown over 110 countries and its total production is over 1500 million tons. After crushing of Sugarcane bagasse is produced. Then after burning of bagasse 2 to 3% SCBA is produced of total Sugarcane production. In India about 10 millions tons of SCBA is produced and hence it is one of an agricultural waste from sugar manufacturing. When juice is extracted from the cane sugar, the solid waste material is known as bagasse. When this waste is burned under controlled conditions, it gives ash having amorphous silica, which has pozzolanic properties. In this study SCBA received from Sonhira cooperative Sugar Factory is collected and its Pozzolanic reactivity is tested by modified Chappell method. The partial size distribution and constituents present in the SCBA are tested by X-ray fluorescence test. Pozzolanic reactivity of SCBA samples is tested by doing calcinations at 4000C, 5000C, 6000C, 7000C, and 8000C for 15 min, 30 min, 60min, 90min, and 120min. & at different grinding levels of 15min, 30min, 60min, 120min, and180min.

Pozzolonic Materials-

A pozzolona is a siliceous and aluminous material which possesses little or no cementitious value but which will, in finely divided form and in presence of water, react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties. The broad definition of a pozzolona imparts no bearing on the origin of material, only in its capability reacting with calcium hydroxide and water. A quantification of this capability is comprised in the term pozzolonic activity. The most commonly used pozzolonas today are industrial by products such as fly- ash, silica fume from silicon smelting, and sugar cane bagasse ash.

Pozzolonic Reaction-

When pozzolonic materials are added to cement the silica SiO_2 present in these materials react with Calcium Hydroxidereleased during the hydration of cement and form additional calcium silicate hydrate (CSH) as new hydration product which improve the mechanical properties of concrete formed and calcium hydroxide (CH) which become obstruct to gaining strength. Pozzolanic materials like SCBA reacts with this CH to again produce CSH.

Cement + H_2O = CSH + CH CH + pozzolonic material = CSH

NEED-

Construction industry is incomplete without cement usage,which produces one ton of CO2 by manufacturing 1 ton of cement, which is about 3% of CO2 emission worldwide. The Production of SCBA also increases the pollution.If SCBA is used in construction as a partial replacement for cement in making concrete or mortar, which reduces environmental impact and reduces the green house effect also increases the carbon credits of the country. For effective use of SCBA it is necessary to find out the reactivity of SCBA.

LITERATURE REVIEW-

Coderio (2008) observed that the pozzolanic activity of the ground ash was directly correlated to its fineness, characterized by its 80% passing size or Blaine specific surface area. From a low pozzolanic activity of less than 50% of the as-received ash, values above 100% could be reached after prolonged grinding times. The application of an ultra-finely ground SCBA produced by vibratory grinding allowed the production of high performance concrete Such addition of SCBA also resulted in improvements in rheology of concrete in the fresh state and resistance to penetration of chloride-ions.

Coderio (2009) presents the results of the processing of sugar cane bagasse ash (SCBA) under controlled calcinationconditions in order to obtain materials with optimum pozzolanic activity. Bagasse samples were burnt in an aired electric oven with a heating rate of 10º C/min, at 350 º C for 3 hrs. And at different temperatures ranging from 400º to 800º C for another 3hrs. For all calcination temperatures the pozzolanic activity,structural state of silica and loss on ignition of the ashes were determined. Moreover, the SCBA with greater pozzolanic activity was characterized by using chemical analysis, scanning electron microscopy, density, specific surface area and chemical reactivity.

OBJECTIVE-

To find out the pozzolanic reactivity of sugarcane bagasse ash by doing calcination at various temperatures and at different grinding levels.

EXPERIMENTAL PROGRAM-

A. Material Used

For this experiment SCBA was collected from the Sonhira Sugar Co-operation industry situated in the Kadegaon Tashil ofSangli District, State of Maharashtra.

B. Chemical Composition of SCBA

Chemical characteristics are found out by doing X ray fluorescence's test on received sample 1 and sample 2 of SCBA. The results of the test are as shown in Table I and Table II respectively.

TABLE I
RESULTS of X-RAY FLUORENSCCNCE TEST: SAMPLE 1

Compound	**Result**	**Unit**	**Amount**
CaO	3.183	%	2.2790
Fe_2O_3	0.470	%	0.3365
K_2O	6.763	%	4.8423
MnO	0.064	%	0.0458
P_2O_5	3.638	%	2.6048
SO_3	2.126	%	1.5222
SrO	0.053	%	0.0379
TiO_2	0.231	%	0.1653
Al_2O_3	5.530	%	3.9595
BaO	0.023	%	0.0164
MgO	6.341	%	4.5402
SiO_2	**111.085**	**%**	**79.537**
Na_2O	0.156	%	0.1169
Total	139.6633	%	100.00

TABLE II
RESULTS of X-RAY FLUORENSCCNCE TEST: SAMPLE 2

COMPOUND	RESULT	UNIT	AMOUNT
CaO	2.081	%	1.5174
Fe2O3	1.063	%	0.7751
K2O	2.645	%	1.9287
MnO	0.061	%	0.0444
P2O5	1.498	%	1.0923
SO3	0.027	%	0.0196
SrO	0.050	%	0.0364
TiO2	0.340	%	0.2479
Al2O3	5.586	%	4.0732
BaO	0.021	%	0.0153
MgO	2.910	%	2.1219
SiO2	**120.743**	**%**	**88.044**
Na2O	0.113	%	0.0823
Total	137.1380	%	100.01

METHODS ADOPTED

A. Grinding

Grinding of SCBA is done on Los Angel's abrasion machine for duration of 30min, 60min, 120min, and 180min.

Total Capacity - 35 liters.
No. Of balls used – 10.
Weight Of each ball – 1.5 Kg.
Speed Of motor – 35 rpm

B. Calcination

Calcination is the process of subjecting a substance to the action of heat, but without fusion, for the purpose of causing some changes in its physical or chemical properties. SCBA samples were burnt in an aired electric oven with a heating rate of 300C/min for different durations of 15min, 30min, 60min & 90min. After this percentage weight loss is calculated for each sample of different durations. This procedure was repeated for 4000C, 5000C, 6000C, 7000C and 8000C.

C. Modified Chappelle Method

It is revised methodology of Chappelle method to evaluate Pozzolanic reactivity of mineral admixture at varying temp. The test consists of placing 1.000 gm. of mineral admixture and 1.000 gm. of calcium oxide in a water volume of 250ml. The solution was kept for 16 hours in an oven at 900C. At the end, CaO content was determined by titration with hydrochloric acid solution & Phenolphthalein as indicator. Fixed CaO expressed the results, which is equal to the difference between 1.000 gm. & the mass of CaO obtained from titration. The sample, which is giving less residual CaO, can fix as Optimum condition. Min 28% of CaO is required for material to be Pozzolona.

RESULTS AND CALCULATIONS-

A. Grinding

The results of weight retained on 75-micron sieve are given as:

Table III

SR. NO.	TIME IN MINUTES	WT. RETAINED ON 75µ SIEVE
1.	15	40%
2.	30	34%
3.	60	30%
4.	120	26%
5.	180	24%

From Table III it is seen that, the percentage of ash sample retained for the time 120 minutes (26%) and 180 minutes (24%) are nearly the same.

B. Calcination

TABLE IV
CALCINATION

Tempeature	Duration (min)	Weight (gms)		Percent loss (%)
		Initial	Final	
400˚C	15	150	140.79	6.14
	30	150	140.78	6.15
	60	155.08	145.49	6.18
	90	140.79	132.08	6.18
500˚C	15	137.5	130.66	4.97
	30	142	133.88	5.71
	60	142.8	134.23	6.00
	90	101.9	95.56	6.22
600˚C	15	132.6	124.2	6.33
	30	146.1	138.7	5.10
	60	148.2	140.7	5.06
	90	153.8	144.3	6.17
700˚C	15	143.66	136.40	5.05
	30	147.27	139.20	5.47
	60	142.87	135.101	5.50
	90	133.87	130.40	2.59
800˚C	15	146.410	139.42	4.77
	30	161.130	152.62	5.28
	60	140.720	132.02	6.18
	90	160.60	151.01	3.97

As from the results shown in Table IV, it is seen that, the percentage weight loss increases initially till 600°C and then remains constant till 800°C.

C. Pozzolanic Reactivity

1. Readings of blank sample of calcium oxide and water when titrated with hydrochloric acid solution in the presence of phenolphthalein indicator.

a. 7.5 ml
b. 11 ml
Avg.= 9.25 ml
Therefore, fixed CaO in grams
= 0.037 x 9.25= 0.34225 for 1 N.

2. Readings of as received sample of SCBA with calcium oxide and water when titrated with hydrochloric acid solution in the presence of phenolphthalein indicator.

a. 6.7 ml
b. 7.9 ml
Avg.=7.3 ml

A) Fixed CaO in grams (for 1 N)
= 0.037 x 6.7 ml = 0.2479 gm.

Consumption with respect to blank sample =0.34225 - 0.2479 = 0.09435 gm

% Consumption = $\frac{0.09435}{0.34225} * 100$ = 27.56 %

(B) Fixed CaO in grams (for 1 N)

= 0.037 x 7.9 ml = 0.2923 gm.

Consumption with respect to blank sample=0.34225 - 0.2923 = 0.04995 gm.

% Consumption = $\frac{0.04995}{0.34225} * 100$ = 14.59 %

Table 1 Pozzolonic reactivity of SCBA

Sr No	Temperature	Time (min)	Normality	Reading (ml)		Consumption		Percentage (%)	
				1st sample	2nd sample	1st sample	2nd sample	1st sample	2nd sample
1	400˚C	15	0.1 N	44.0	45.5	0.1794	0.1739	52.43	50.83
		30	0.1 N	24.5	25.0	0.2516	0.2497	73.50	72.97
		60	1 N	2.9	4.5	0.2349	0.1790	58.64	52.43
		90	1 N	4.5	6.9	0.1750	0.0860	51.35	25.40
2	500˚C	15	0.5 N	12.1	12.8	0.1184	0.1054	34.59	30.8
		30	0.5 N	16.9	16.3	0.0296	0.0407	8.60	11.89
		60	0.5 N	11.0	19.0	0.1317	0.0090	40.54	27.00
		90	1 N	15.0	5.1	0.2100	0.1530	62.16	44.86
3	600˚C	15	1 N	6.4	8.0	0.1050	0.0460	30.81	13.50
		30	1 N	5.5	4.9	0.1380	0.1609	40.54	47.00
		60	1 N	3.7	3.3	0.2050	0.2200	60.00	64.30
		90	1 N	2.5	2.6	0.2497	0.2460	**72.97**	**71.90**
4	700˚C	15	1 N	5.3	5.7	0.1460	0.1310	42.70	38.37
		30	1 N	3.9	4.5	0.1970	0.1750	57.83	51.35
		60	1 N	4.1	3.8	0.1900	0.2010	55.67	58.91
		90	1 N	4.2	3.5	0.1860	0.2120	54.60	62.16
5	800˚C	15	1 N	6.5	5.1	0.1010	0.1530	29.72	44.86
		30	1 N	5.4	3.9	0.1420	0.1970	41.62	57.83
		60	1 N	6.4	2.2	0.1050	0.2600	30.80	76.20
		90	1 N	4.7	10.6	0.1680	0.0500	49.18	14.60

Table V shows the reactivity of SCBA samples after calcinated at different temperatures for different time spans. From this data we can clearly come to inference that SCBA after calcinated at 6000C for 90 mints gives pozzolanic reactivity up to 72%.

TABLE VI
OPTIMUM GRINDING LEVEL

Sample Type	**Grinding level (min)**	**Sample**		**Normality**	**Consumption**		**Percentage**	
		1	**2**		**1**	**2**	**1**	**2**
Grinding	15	7.8	5.5	1 N	0.0537	0.13875	15.69	40.54
	30	4.1	5.6	1 N	0.1905	0.13505	55.66	39.45
	60	7.9	2.5	1 N	0.0499	0.2498	14.57	72.98
	120	1.2	1.1	1 N	0.2979	0.3015	87.04	88.09
	180	1.3	1.4	1 N	0.2942	0.2904	85.96	84.85

Table VI shows the reactivity of SCBA samples after the grinding at various time spans. From this data we can clearly come to inference that SCBA after grounded for 120 mints gives pozzolanic reactivity up to 88%.

TABLE VII
OPTIMUM LEVEL GRINDING (120 MINTS) + CALCINATION (@ 600°C for 90MINTS)

Sample Type	Grinding level (min)	Sample		Normality	Consumption		Percentage	
		1	2		1	2	1	2
Final	120	0.9	1.0	1N	0.3085	0.30525	90.27	89.18

Table VII gives the optimum reactivity of SCBA at optimum calcination temperature and at optimum grinding level that is 90%.

CONCLUSIONS-

1. According to Chappelle test and results obtained from it, the maximum consumptions of Calcium Oxide after calcination is obtained at 600 degrees of burning for 90 minutes (72.97% and 71.9%).

2.For as received sample the % consumptions are 27.56% and 14.59%. Hence after calcination the % consumption has shown remarkable rise indicating increase in pozzolonic reactivity of bagasse ash.After Grinding of bagasse again rise in % consumption was seen with 87.04% and 88.09% for 120 mints of grinding of ash.Thus, after performing grinding and calcination the pozzolonic reactivity increases.

FUTURE SCOPE-

To find the optimum replacement % of bagasse ash with respect to achieve maximum compressive strength & workability as compared to traditional concrete.

To do the cost analysis that is feasibility of the bagasse ash use in concrete

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