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Experimental Study on Bagasse Ash in Concrete

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Abstract: The utilization of industrial and agricultural waste produced by industrial processes has been the focus of waste reduction research for economical, environmental, and technical reasons. Sugar-cane bagasse is a fibrous waste-product of the sugar refining industry, along with ethanol vapor. This waste product (Sugar-cane Bagasse ash) is already causing serious environmental pollution, which calls for urgent ways of handling the waste. Bagasse ash mainly contains aluminum ion and silica. In this paper, Bagasse ash has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 15% and 25% by weight of cement in concrete. Fresh concrete tests like compaction factor test and slump cone test were undertaken was well as hardened concrete tests like compressive strength, split tensile strength, flexural strength and modulus of elasticity at the age of seven and 28 days was obtained. The result shows that the strength of concrete increased as percentage of bagasse ash replacement increased.

Index Terms: bagasse ash, concrete

Introduction

Ordinary Portland cement is recognized as a major construction material throughout the world. Researchers all over the world today are focusing on ways of utilizing either industrial or agricultural waste, as a source of raw materials for industry. This waste, utilization would not only be economical, but may also result in foreign exchange earning and environmental pollution control[1].Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials[2]. Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in electric generation industry[3]. When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties[4]. A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement[5]. Therefore it is possible to use sugarcane bagasse ash (SCBA) as cement replacement material to improve quality and reduce the cost of construction materials such as mortar, concrete pavers, concrete roof tiles and soil cement interlocking block.

The present study was carried out on SCBA obtained by controlled combustion of sugarcane bagasse, which was procured from the Tamilnadu province in India. Sugarcane production in India is over 300 million tons/year leaving about 10 million tons of as unutilized and, hence, wastes material. This paper analyzes the effect of SCBA in concrete by partial replacement of cement at the ratio of 0%, 5%, 10%, 15% and 25% by weight. The experimental study examines the compressive strength, split tensile strength, flexural strength, young's modulus and density of concrete. The main ingredients consist of Portland cement, SCBA, river sand, coarse aggregate and water. After mixing, concrete specimens were casted and subsequently all test specimens were cured in water at seven and 28 Days.

Materials and methods

The materials used in this investigation are:

Cement: The most common cement is used is ordinary Portland cement. Out of the total production, ordinary Portland cement accounts for about 80-90 percent. Many tests were conducted to cement some of them are consistency tests, setting tests, soundness tests, etc.

Fine Aggregate: Locally available free of debris and nearly riverbed sand is used as fine aggregate. The sand particles should also pack to give minimum void ratio, higher voids content leads to requirement of more mixing water. In the present study the sand conforms to zone II as per the Indian standards[6]. The specific gravity of sand is 2.68. Those fractions from 4.75 mm to 150 micron are termed as fine aggregate, and the bulk density of fine aggregate (loose state) is 1393.16kg/m^3 and rodded state is 1606.84kg/m^3.

Coarse Aggregates: The crushed aggregates used were 20mm nominal maximum size and are tested as per Indian standards[6] and results are within the permissible limit. The specific gravity of coarse aggregate is 2.83; the bulk density of coarse aggregate (loose state) is 1692.31kg/m^3 and rodded state is 1940.17kg/m^3.

Water: Water available in the college campus conforming to the requirements of water for concreting and curing as per IS: 456-2000[9].

Sugarcane Bagasse Ash: The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicellulose and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO_2). In spite of being a material of hard degradation and that presents few nutrients, the ash is used on the farms as a fertilizer in the sugarcane harvests. In this sugarcane bagasse ash was collected during the cleaning operation of a boiler operating in the Sakthi Sugar Factory, located in the city of Sathyamangalam, Tamilnadu.

Table 1 Composition of Bagasse

COMPONENT	MASS%
SiO_2	78.34
Al_2	8.55
Fe_2O	3.61
CaO	2.15
Na_2O	0.12
K_2O	3.46
MnO	0.13
TiO_2	0.50
BaO	<0.16
P_2O_5	1.07
LOSS OF IGNITION	0.42

Experimental work

In this experimental work, a total of 180 numbers of concrete specimens were casted. The specimens considered in this study consisted of 36 numbers of 150mm side cubes, 108 numbers of 150mm diameter and 300mm long cylinders, and 36 numbers of 750mm x 150mm x 150mm size prisms. The mix design of concrete was done according to Indian Standard guidelines[6-9] for M 20 grade for the granite stone aggregates and the water cement ratio are 0.48.

Based upon the quantities of ingredient of the mixes, the quantities of SCBA for 0, 5, 10, 15, 20 and 25% replacement by weight were estimated. The ingredients of concrete were thoroughly mixed in mixer machine till uniform thoroughly consistency was achieved. Before casting, machine oil was smeared on the inner surfaces of the cast iron mould. Concrete was poured into the mould and compacted thoroughly using table vibrator. The top surface was finished by means of a trowel. The specimens were removed from the mould after 24h and then cured under water for a period of 7 and 28 days. The specimens were taken out from the curing tank just prior to the test. The tests for compressive, split tensile strength were conducted using a 2000kN compression testing machine, the modulus of elasticity the test conducted using a compression testing machine and compressometer (strain measurements). For modulus of rupture was conducted using 1000kN universal testing machine. These tests were conducted as per the relevant Indian Standard specifications[6-9].

Experimental results

The strength results obtained from the experimental investigations are showed in tables. All the values are the average of the three trails in each case in the testing program of this study. The results are discussed as follows.

Workability

A high-quality concrete is one which has acceptable workability (around 6.5 cm slump height) in the fresh condition and develops sufficient strength. Basically, the bigger the measured height of slump, the better the workability will be, indicating that the concrete flows easily but at the same time is free from segregation. Maximum strength of concrete is related to the workability and can only be obtained if the concrete has adequate degree of workability because of self compacting ability. The workability of C0 and N series concrete are presented in Figure 2. The figure shows the influence of SCBA content on the workability of mixtures at constant water to binder ratio of

0.48. The results show that unlike the C0 series, all investigated SCBA mixtures had high slump values and acceptable workability. This may be due to the increasing in the surface area of sugarcane ash after adding SCBA that needs less water to wetting the cement particles.

TABLE 2
FRESH CONCRETE

Sample Designation	% of SCBA	Workability	
		Slump(mm)	Compaction factor
C0	0	60	0.95
N1	5	187	0.96
N2	10	200	0.96
N3	15	220	0.97
N4	20	225	0.97
N5	25	230	0.97

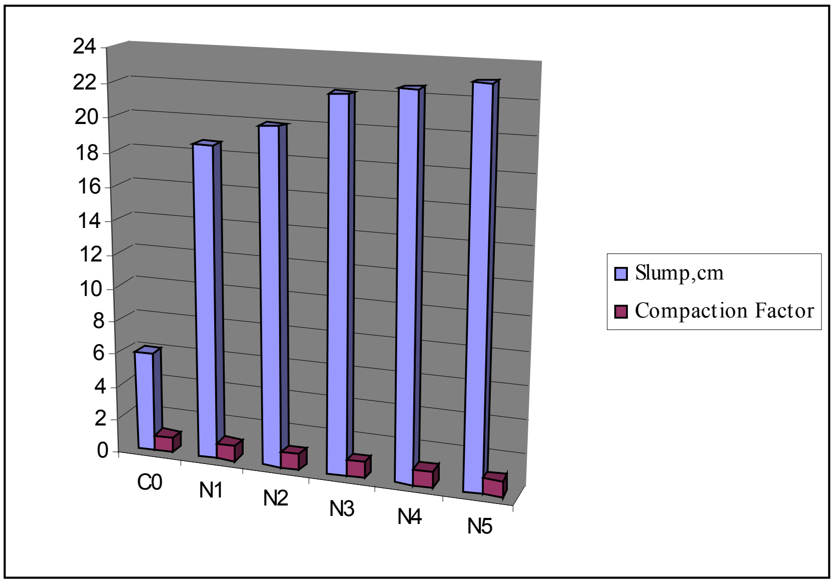

FIGURE 1
WORKABILITY

The strength test results obtained for concrete cube, cylinder and prism specimens with partial replacement of SCBA shown in Table 2 and 3. From the table, it is clear that the addition of SCBA in plain concrete increases its strength under compression, tension, young's modulus, and flexure up to 10% of replacement after that strength results was decreases.

TABLE 3
STRENGTH RESULTS OF SCBA CONCRETE AT 7 DAYS

Sample Designation	**% of SCBA**	**Compressive Strength** (MPa)	**Split Tensile Strength** at (MPa)	**Flexural Strength** (MPa)	**Modulus of Elasticity** (MPa)	**Bulk Density** (kg/m^3)
C0	0	13.80	0.693	3.63	22800	2535.30
N1	5	15.83	0.97	3.35	23100	2541.23
N2	10	12.33	0.90	3.19	23000	2517.52
N3	15	8.79	0.70	3.04	21900	2494.81
N4	20	8.30	0.65	2.75	20100	2400.01
N5	25	7.55	0.42	2.30	19800	2396.04

TABLE 4
STRENGTH RESULTS OF SCBA CONCRETE AT 28 DAYS

Sample Designation	**% of SCBA**	**Compressive Strength** (MPa)	**Split Tensile Strength** at (MPa)	**Flexural Strength** (MPa)	**Modulus of Elasticity** (MPa)	**Bulk Density** (kg/m^3)
C0	0	21.47	1.526	3.460	30010	2546.17
N1	5	29.50	1.94	3.74	29200	2581.72
N2	10	24.70	1.59	3.56	25800	2505.67
N3	15	19.32	1.45	3.38	21000	2429.62
N4	20	18.85	1.34	3.18	19500	2410.21
N5	25	17.73	1.24	3.02	18500	2400.00

Comparison of the results from the 7, and 28 days samples shows that the compressive strength, tensile strength and also flexure increases with SCBA up to 1.0% replacement (N1) and then it decreases, although the results of 2.0% replacement (N4) is still higher than those of the plain cement concrete (C0). It was shown that the use of 2.0% SCBA decreases the compressive strength to a value which is near to the control concrete. This may be due to the fact that the quantity of SCBA (pozzolan) present in the mix is higher than the amount required to combine with the liberated lime during the process of hydration thus leading to excess silica leaching out and causing a deficiency in strength as it replaces part of the cementitious material but does not contribute to strength. Also, it may be due to the defects generated in dispersion of SCBA that causes weak zones. In Modulus of Elasticity decreases with increase in SCBA (Fig-3) and also the density of concrete with SCBA were decreases.

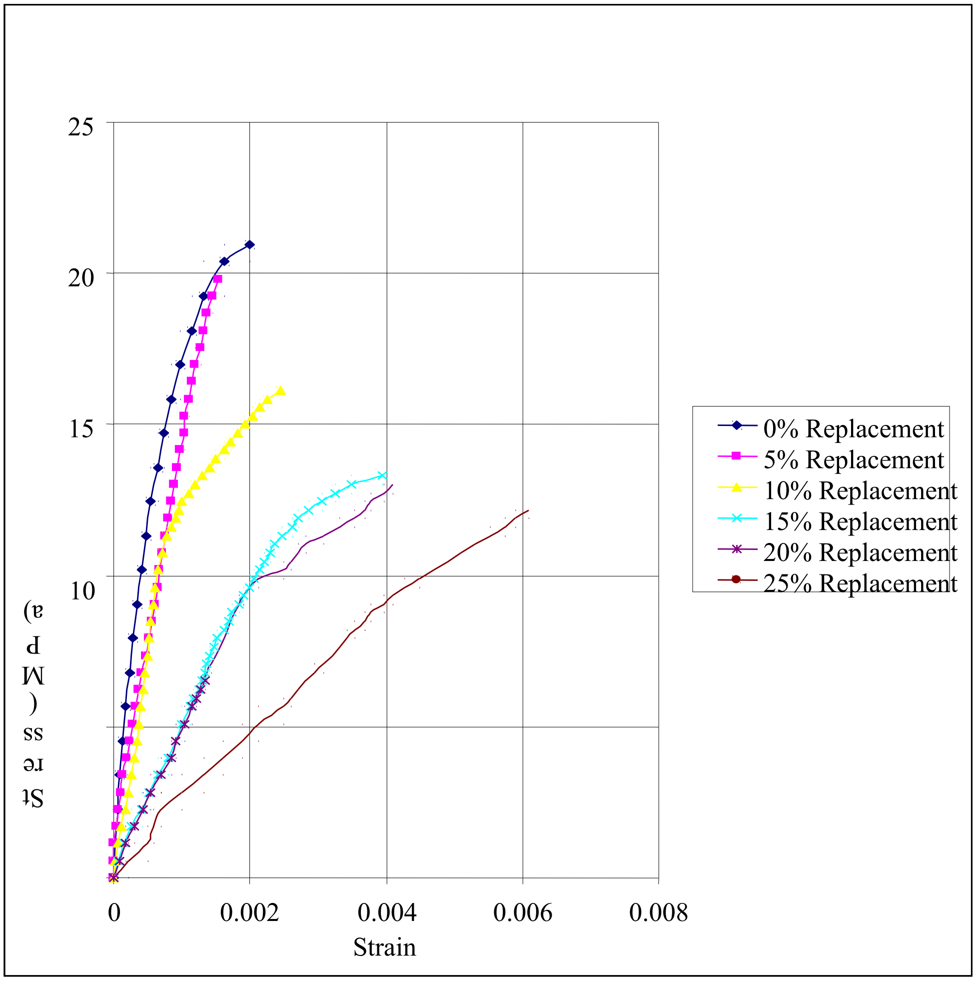

FIGURE 2
STRESS-STRAIN RELATIONSHIP

Conclusions

The results show that the SCBA in blended concrete had significantly higher compressive strength, tensile strength, and flexural strength compare to that of the concrete without SCBA. It is found that the cement could be advantageously replaced with SCBA up to maximum limit of 10%. Although, the optimal level of SCBA content was achieved with 1.0% replacement. Partial replacement of cement by SCBA increases workability of fresh concrete; therefore use of super plasticizer is not substantial. The density of concrete decreases with increase in SCBA content, low weight concrete produced in the society with waste materials (SCBA).

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