Experimental Research on Concrete Strength Properties Using Sugarcane Bagasse Ash

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Abstract- Demand and consumption of sand is increasing day by day which has led researchers and scientists to search for locally available alternatives that can replace sand partially and are eco-friendly and contribute towards waste management. Sugarcane bagasse ash, a waste industrial by product is one such material recognize for use as a substitution of natural sand. This study investigates the suitability of sugarcane bagasse ash (SCBA) as a partial sand substitute in concrete. In this study, sugarcane bagasse ash was partially replaced in the ratio of 0%, 5%, 10%, 15% and 20% by weight of sand in concrete. The bagasse ash used for the research work is obtained from Mahatma Sugar Factory, Wardha. M30 grade of concrete was used for the experimental analysis. The effect of replacement of sand by bagasse ash on properties like workability for fresh concrete was tested and for hardened concrete compressive strength, split tensile strength and flexural strength were determined. Results of this investigation indicate that maximum strength of concrete could be attained at 10% replacement of sand with SCBA.

Keywords —Sugarcane Bagasse Ash, Sand replacement, Workability, Strength

I. INTRODUCTION

Sugarcane bagasse ash is a by-product of sugar mills discovered after the burning of sugarcane bagasse. The disposal of this waste is already causing environmental issues in the area of the sugar mills. A sugar factory produces nearly three tonnes of wet bagasse for every ten tonnes of sugarcane crushed. When bagasse waste is burned in a controlled manner, amorphous silica ash with pozzolanic properties is generated. The combustion produces ashes that are high in unburned matter such as silica and alumina oxides.

India alone generates approximately 90 million of bagasse as a solid waste from the sugarcane industry [1]. The other major issue is the disposal of solid waste produced by industrial production. The accumulation of wastes is not only a burden on industry, but it also has a negative impact on the environment. A few research on the use of bagasse ash collected directly from the industries to study pozzolanic operation and their suitability as binders by partially replacing cement have been conducted in the past. Since global consumption of natural river sand is very high due to wide use of concrete, natural sand supply has been reduce in recent decades. The aim of this study was to investigate the use of SCBA as a partial substitute for sand in cement concrete. This paper examines the effect of SCBA in concrete by partial replacement of sand at the ratio of 0%, 5%, 10%, 15% and 20% by weight. The experimental study inspects the workability, compressive strength, split tensile strength and flexural strength of concrete.

II. LITERATURE REVIEW

"Utilization of Bagasse Ash as a Partial Replacement of Fine Aggregate in Concrete", (2012) by Prashant O Modani, M R Vyawahare

In this paper, untreated bagasse ash has been partially replaced in the ratio of 0%, 10%, 20%, 30% and 40% by volume of fine aggregate in concrete. Fresh concrete tests like compaction factor test and slump cone test were undertaken along with hardened concrete tests like compressive strength, split tensile strength and sorptivity. The result shows that bagasse ash can be a suitable replacement to fine aggregate [1].

"Use of Sugar cane Bagasse Ash as a Fine Aggregate in Cement Concrete", (2019) by Ali Aizaz Dayo, Aneel Kumar, Anees Raja, Naraindas Bheel, Zubair Hussain Shaikh

The main focus of this research work was to examine the fresh property and mechanical concrete properties by replacing fine aggregate by SCBA. A total of 60 concrete cylinders were prepared with 1:2:4 proportion with 0.50 water-cement ratio and immerged in water on 7 and 28 days. Finally, these concrete cylinders were tested on UTM. The slump value of concrete decreased with increased in the amount of SCBA in cement concrete. The results analysed that the compressive and tensile strength of the concrete

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samples increased by 7.90% and 14% at 10% of SCBA as sand substitute materials in cement concrete after 28 days [2].

“Experimental Study on Sugarcane Bagasse Ash in Concrete”, (2010) by R. Srinivasan and K. Sathiya

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. 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 [3].

“Evaluation of Bagasse Ash as Supplementary Cementitious Material”, (2007) by Ganesan, K., Rajagopal, K., & Thangavel K.

In this study the effects of BA content as partial replacement of cement on physical and mechanical properties of hardened concrete are reported. The properties of concrete investigated include compressive strength, splitting tensile strength, water absorption, permeability characteristics, chloride diffusion and resistance to chloride ion penetration. The test 12 results indicate that BA is an effective mineral admixture, with 20% as optimal replacement ratio of cement [4].

“Study the Effect of Sugarcane Bagasse Ash Waste on Behaviour of Cement Mortar and Concrete as the Partial Replacement”, (2018) by Arun kumar Jha, Anil Sanodiya, Rakesh Rathor

In this exploratory research work solid 3D squares, shafts and chambers of M20 review were threw with various level of Bagasse fiery debris substance and tried to look at different properties of solid like workability, compressive quality. The concrete mortar comprising distinctive level of Bagasse fiery remains likewise analyze by leading tests like compressive quality, setting time and consistency test. Sugar stick bagasse fiery remains was mostly supplanted with bond at 3, 6, 9, 12, 15, 18 and 21 % by weight of bond in mortar and 5, 10, 15 and 20 % by weight of concrete in concrete. From the outcomes we can presume that ideal measure of sugar stick bagasse fiery debris that can be supplanted with bond is 5-10% by weight in cement and 9-12 % by weight in concrete mortar with no admixture [5].

III. MATERIALS

The concrete mixture mainly composed of cement, fine aggregate, coarse aggregate and water with or without a suitable admixture in required proportion. The characteristics of each of these materials should be studied for mix design of concrete. The materials can be used only if it meets specifications in the code.

Cement – Portland-Pozzolana cement manufactured by Birla Cement Limited used for casting all the specimens should be confirming to IS 1489 (Part 1): 1991. Properties of PPC are given in Table 1.

Table 1. Physical Properties of Cement

Sr. No.	Property of cement	Value
1	Fineness	313 m^2/kg
2	Specific gravity	3.14
3	Initial setting time	55 mins
4	Final setting time	320 mins

Fine Aggregate – Provincially accessible free of detritus and virtually stream bed sand is used as fine aggregate. In the current study the sand corresponds to zone II as per the Indian standards. The specific gravity of sand is 2.64.

Coarse Aggregate – The scale of the crushed aggregate used was 20 mm to 10 mm, verified by IS: 10262, IS: 383. The specific gravity is 2.70.

Sugarcane Bagasse Ash (SCBA) - 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 [1]. The chemical composition of the waste after incineration is dominated by Silicon Dioxide (SiO2). The ash is used on farms as a fertilizer in the Sugarcane Baggage Ash harvests, despite being a substance of an extreme degradation and that contains little nutrients.

Table 2. Properties of sugarcane bagasse ash

Property	Value
Fineness modulus	1.78
Specific gravity	1.44

Table 3. Chemical properties of sugarcane bagasse ash

Compound	Mass (%)
SiO_2	64.55
Al_2O_3	7.97
Fe_2O_3	4.53
CaO	6.4
K_2O	3.77
MgO	3.13
SO_3	0.86
Loss of Ignition	3.29

Water - Good potable water available in the site is used for the construction purpose which conforming to the requirements of water for concreting and curing as per IS: 456-2000 [6].

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IV. METHODOLOGY

First, we studied the material and data required for the study, estimated the amount of material needed for the study, and then began searching for the locally available materials in this process. In this process, we get cement, coarse aggregate and fine aggregate, but sugarcane bagasse ash has to be recovered from Mahatma Sugar Factory, Wardha. We collected sugarcane bagasse ash and its chemical characteristics from them.

Mix design – Firstly, by IS process, we tested the cement including fineness test, consistency test, setting test and compression strength test. According to IS 383-1970, we have carried out sieve analysis tests of fine aggregate and coarse aggregate and graded coarse and fine aggregate accordingly. The basic gravity and water absorption of coarse aggregate and fine aggregate were determined. Fineness modulus checking of the fine aggregate used in the analysis was also performed. Specific gravity, water absorption, fineness modulus of SCBA have been measured. After that, by replacing different amounts of natural sand with SCBA, we have design concrete of M 30 grade and then measure and compare the compressive strength of these replaced content concrete at 7 days, 14 days and 28 days.

Mixing – Mixing is conducted by hand. The cement materials are thoroughly blended and the aggregates are then added to this, followed by the slow and steady addition of water, and then fully combined. Until a mixture of uniform colour and consistency that is ready for casting is obtained, the mixing has to be done properly.

Casting of specimen – The moulds are polished, and before concrete is poured into the mould, oil is applied to the mould. On the level platform, the moulds are put. In the moulds, the fully mixed green concrete is poured in. Excess concrete has been removed, verifying IS: 516-1969, and the top surface is levelled. Here 45 number of cubes, 30 number of cylinders and 30 number of beams are casted.

Curing the specimen – The specimens in the mould are kept undisturbed in moulds for 24 hours and then de-moulded. Without cracking corners, de-moulding must be done carefully. They must be cured in water confirming IS: 516-1969 for the necessary time.

Testing – The strength tests such as slump test, compressive strength test, split tensile strength test and flexural strength test are conducted on concrete.

V. TEST METHODS

A total of three specimens were tested for each concrete property at the end of each curing cycle. According to Indian standards, compressive strength tests were performed on 150mm cube specimens, split tensile strength tests were performed on 150mm diameter and 300mm height cylindrical specimens, and flexural strength tests were performed on 150 x 150mm concrete beams with a span usually 500mm.

VI. RESULTS AND DISCUSSION

Slump test: The slump test is used to determine the consistency of fresh concrete until it hardens. It is used to measure the workability of freshly mixed concrete and, as a result, the ease with which it flows. Table 4 depicts the workability of different mixtures. The maximum value of slump measured was 87mm at 0% SCBA and the minimum value of slump recorded was 39mm at 20% SCBA in concrete. With increasing SCBA content, workability of concrete decreases.

Table 4. Slump test results

Sample	Slump value (mm)
M0	87
M5	74
M10	68
M15	52
M20	39

Compressive strength test: The compressive strength of concrete with a percentage of natural sand substituted by bagasse ash of 0%, 5%, 10%, 15% and 20% at the ages of 7, 14 and 28 days was discovered. As the curing time progressed, the compressive strength improved as well. At 28 days, the control combination had a compressive strength of 31.6 MPa. Table 5 displays the effects of the compressive strength tests for all mixes. The compressive strength was increased by 7.03% at 10% of SCBA used as sand substituent material in concrete after 28 days of curing. The minimum value of compressive strength reported was 28.89 MPa at 20% SCBA as fine aggregate replacement in concrete. The minimum value of compressive strength was reduced by 8.57% at 20% SCBA after 28 days of curing. Adding more than 10% SCBA in concrete reduces the compressive strength of concrete.

Table 5. Compressive strength test results

Sample	Compressive strength (N/mm^2)		
	7 days	14 days	28 days
M0	18.80	26.54	31.6
M5	17.76	25.68	31.95
M10	16.91	24.81	33.82
M15	15.64	23.54	29.97
M20	14.37	22.28	28.89

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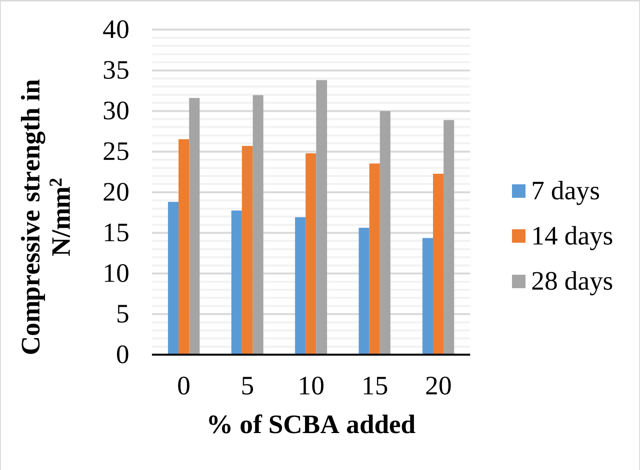

Figure 1. Compressive Strength of Concrete

Split tensile strength test: Table 6 shows the tensile strength outcome for all of mixes after 7 days and 28 days of curing. At 7 and 28 days, the control combination had a split tensile strength of 2.56 and 4.19 MPa respectively. When the effect of SCBA on concrete tensile strength was investigated, it was discovered that as the replacement of SCBA increases, the development of tensile strength of mixes decreases.

Table 6. Split tensile strength test results

Sample	Split tensile strength (N/mm^2)	
	7 days	28 days
M0	2.56	4.19
M5	2.49	3.99
M10	2.41	3.85
M15	2.26	3.79
M20	2.18	3.71

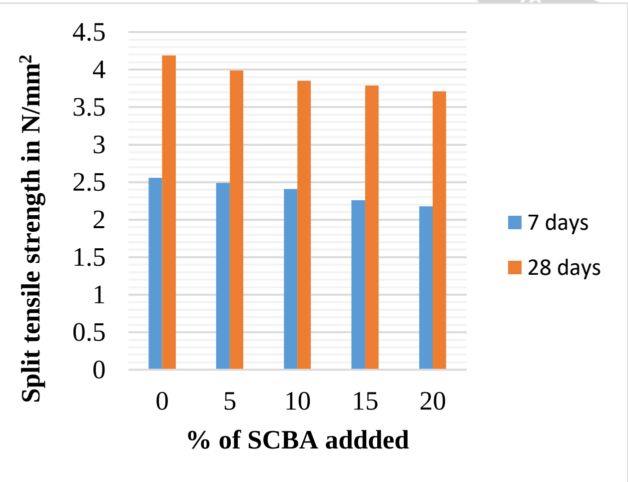

Figure 2. Spilt Tensile Strength of Concrete

Flexural strength test: To measure the concrete's flexural strength, a beam specimens are casted. The test specimens are cured for 7 days and 28 days before being tested for full load. The difference in flexural strength for different replacements in comparison to regulated concrete for 7 days and 28 days is provided as result in the table 7. At 7 and 28 days, the control combination had a flexural strength of 3.15 and 4.06 MPa respectively. With increasing SCBA content, the bagasse ash concrete gains flexural strength that is comparable but less than that of the controlled concrete. Since bagasse ash particles are spherical in nature, it's thought to be due to weak interlocking between the aggregates.

Table 7. Flexural strength test results

Sample	Flexural strength (N/mm^2)	
	7 days	28 days
M0	3.15	4.06
M5	3.03	3.89
M10	2.96	3.82
M15	2.83	3.73
M20	2.6	3.61

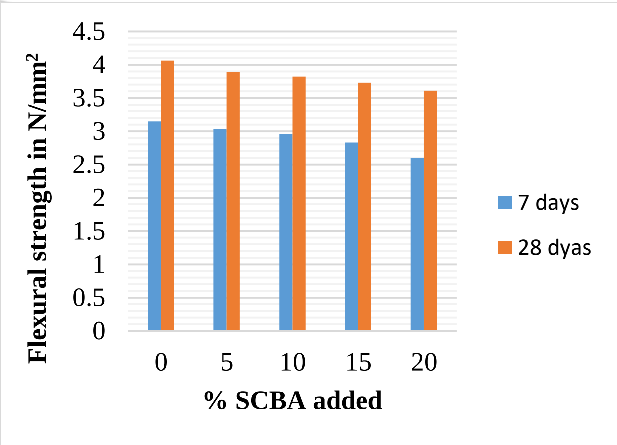

Figure 3. Flexural Strength of Concrete

VII. CONCLUSION

The following conclusions about the use of SCBA seem to be true based on the experimental work done and the interpretation of the data:

1. Workability of concrete decreases as the amount of SCBA as fine replacement level of aggregate in concrete increases.
2. The finding indicate that when SCBA was used as a partial substitute for sand in concrete up to 10%, the concrete's strength was substantially higher than when no SCBA was used.
3. The compressive strength was increased by 7.03% at 10% of SCBA used as sand substituent material in concrete after 28 days of curing.
4. It was found that adding more than 10% SCBA in concrete lowers the compressive strength.
5. It was discovered that SCBA could be used to replace natural sand up to a maximum of 10%.

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