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An Experimental Study on Compressive Strength of Concrete by Partial Replacement of Cement with SCBA

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***Abstract*: The utilization of industrial and agricultural waste produced by industrial Processes have been the focus of waste reduction research for economic, 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 study, sugarcane Bagasse ash has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 10%, 15%, 20% and 25% by weight of cement in concrete. Fresh concrete tests like slump cone test were undertaken and as was well as hardened concrete test compressive strength at the age of 7 and 28 days was obtained. The result shows that the strength of concrete. In this present study SCBA has been partially replaced in the ratio of 0%, 10%, 15%, 20% and 25% by weight of cement in concrete. Concrete specimens were cured in normal water and NaCl solution comparison is made between them**

***Keywords*: Concrete, sugar cane bagasse ash, sugar cane bagasse concrete, ecofriendly concrete.**

1. Introduction

Utilization of agricultural and industrial by-products in concrete production has become an attractive to the researchers over the entire 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. Currently, many countries are using pozzolanic materials in concrete structures for improving compressive strength and reducing the cost of concrete. Approximately 1500 million tons of sugarcane is annually produced over all the world which leave about 40-45 % bagasse after juice crushing for sugar industry giving an average annual production of 675 million tons of bagasse as a waste material. It is proved that the improved compressive strength depends on both physical and chemical effects of the SCBA. The physical effect (or the so-called filler effect) is concerned with the packing characteristics of the mixture, which in turn depends on the size, shape, and texture of the SCBA particles. The chemical effect relates to the ability of the SCBA to provide reactive siliceous and/or aluminous compounds to participate in the pozzolanic reaction with calcium hydroxide (an unfavorable product from cement hydration) and water. The product of such reaction is called calcium silicate hydrate, a compound known to be responsible for compressive strength in cement-based materials. 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, and only a few studies have been reported on the use of bagasse ash as a pozzolanic material in respect of the cement past. There is a continuous increase in the production of sugar worldwide. Utilization of such agro-industrial by-products as cement replacement materials CRMs in concrete will not only save the environment; but also, will reduce the cement production and consequently the high energy consumption, reduce the CO2 emission, improve the mechanical properties and durability of the produced concrete and reduce the cost of concrete.

1) Sugar Cane Bagasse Ash (SCBA):

Sugarcane bagasse ash, a by-product of sugar factory found after burning of sugarcane bagasse, which in turn is found after the extraction of all economical sugar from sugarcane. It is tested for its pozzolanic property and has been found to improve the compressive strength of concrete when it is replaced in certain percentage. The cementitious materials act as mineral admixtures, actually Mineral admixtures refers to the finely divided materials which are added to obtain specific engineering properties to cement mortar and concrete. Unlike chemical admixtures, they are used in relatively large amounts as replacement of cement and or of fine aggregate in concrete. Mineral admixtures are mostly pozzolanic materials. Sometimes these admixtures may also possess self-cementitious properties in addition to being pozzolanic. These admixtures are available in abundance at a much lower cost compared to chemical admixtures.

2) Scope of Work

The Present Work is carried out to analyze the compressive strength of M 40 Grade concrete under Normal Curing and NaCl Curing with Varying Percentages of Sugar Cane Bagasse Ash.

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Fig. 1. Sugar cane bagasse ash from uyyuru sugar factory.

2. Literature Review

[1] Mrs.U.R.Kawade, (2013) had conducted study on Effect of use of Bagasse Ash on Strength of Concrete. In this paper SCBA has been partially replaced in the ratio of 0%, 10%, 15%, 20%, 25% and 30% by weight of cement in concrete. They conducted tests on different grades of concrete M20 and M30. Compressive strength test of hardened concrete at the age of 7, 28, 60 and 90 days were conducted. It is found that the cement could be advantageously replaced with SCBA up to maximum limit of 15%. [2] R. Srinivasan, (2010) conducted a study on bagasse ash in Concrete. 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. They conducted tests on M20 grade of concrete and Compressive strength, split tensile strength, Flexural strength were obtained at 7 and 28 days. It is found that the cement could be advantageously replaced with SCBA up to maximum limit of 10%. [3] Lavanya M.R et al., (2012) conducted an Experimental study on the compressive strength of concrete by partial replacement of cement with sugarcane bagasse ash. The tests were conducted as per Bureau of Indian Standards (BIS) codes to evaluate the suitability of SBA for partial replacements up to 30% of cement with varying water cement (w/c) ratio. Compressive strengths (7, 14 and 28 days) were determined. The results showed that the addition of sugarcane bagasse ash improves the strengths in all cases. The maximum strength increase happens at 15% with 0.35 w/c ratio. [4] T. Shafana, conducted a research on possibility of using sugarcane bagasse ash as replacement of fine aggregate in concrete. They partially replaced 10%, 15%, 20%, 25% and 30% of natural sand with SCBA. They compared compressive strength, tensile strength and flexural strength with those of concrete made with natural fine aggregate. The test results indicate that it is possible to manufacture concrete containing sugarcane bagasse ash with characteristics similar to those of natural river sand aggregate concrete, provided that the percentage of sugarcane bagasse ash as fine aggregate is limited to 10 percent.

3. Experimental Investigation

1) Materials

The cement used was Ordinary Portland Cement (ULTRATECH 53 grade). The cement procedure was tested for physical requirements in accordance with IS:12269-1987. Fine aggregate used are of Natural River sand and is obtained from nearest supplier in Gudivada. The maximum size of coarse aggregates of 20 mm are used. The coarse aggregates are of crushed granite aggregates obtained from nearest crusher unit. The Fine aggregate is confirming to Zone – II. The Super Plasticizer used is CONPLAST SP 430 and is of PCE Based Chemical Admixture. The Sugar Bagasse Ash is obtained from KCP Sugar Factory, Uyyuru. Fresh portable water free from organic matter and oil is used in mixing the concrete.

Table 1
Properties of materials

Material	**Specific gravity**	**Specific Surface Area/Fineness modulus**
Cement	3.12	294 m^2/kg
Sugar Cane Bagasse Ash	2.20	2500 m^2/kg
Sand	2.64	2.68
Coarse aggregate	2.70	7.42

2) Preparation of diluted 5% NaCl solution:

5% NaCl solution is prepared by adding 500 grams of NACL to 10 liters of diluted water. The pH value of 5% NACL solution was 8.2. The constant pH value was maintained throughout the project.

4. Methodology

The mix design is prepared according to the guidelines in the code IS 10262 - 2019. The W/C ratio for M40 grade was taken as 0.40. Several trail mixes have been done to finalize the mix ratios for M 40 Grade Concrete. The final mix proportion quantities are given in the Table.2

Table 2
Mix proportion Details

Component	**Value**
Cement	380 kg/m^3
Fine Aggregate	674 kg/m^3
Coarse Aggregate	1209 kg/m^3
Water	152 kg/m^3
Super Plasticizer	1% by Weight of Cement

Table 3
Trail mix details

Trial No	**Cement (%)**	**Sugar Cane Bagasse Ash (%)**	**FA (%)**	**CA (%)**
1	100	0	100	100
2	95	5	100	100
3	90	10	100	100
4	85	15	100	100
5	80	20	100	100
6	75	25	100	100

The main objective of the present investigation is to observe the performance of concrete with Sugar Cane Bagasse Ash as a Partial replacement of Cement. Performance of the concretes was assessed by Workability and compressive strength under Two Different Curing conditions ie., Normal Curing and NaCl Curing. The specimens were tested for Workability compression and split tensile strengths 7 and 28 days. For calculating the compressive strength, cube specimens are casted of size 150mm x 150mm x 150mm. For testing fresh concrete workability is the main property of concrete. Workability of concrete is calculated by Slump Cone method. The strengths

were obtained by considering the average of three replicate specimens.

The trail mixes finalized are shown below in Table.3

Table.3 Trail mix details

1) Workability of Concrete:

The workability of concrete is observed by the Slump Cone method and range of slump was selected as 25-100mm.

Table 4
Slump Cone Results

Mix	Slump (mm)
NC	110
SCBA (5%)	109
SCBA (10%)	107
SCBA (15%)	104
SCBA (20%)	101
SCBA (25%)	98

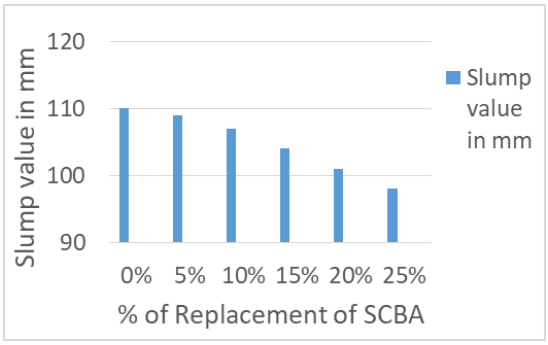

Fig. 2. Variation of slump

2) Compressive Strength

Compressive strength is obtained by applying crushing load on the cube surface. So it is also called as Crushing strength. Compressive strength of concrete is calculated by casting 150mm x 150mm x 150mm cubes. 6 number of cubes were casted for each trail. The test results are presented here for the Compressive strength of 7 days and 28 days of testing. An Average value of 3 cubes were taken to determine the Compressive Strength of Concrete.

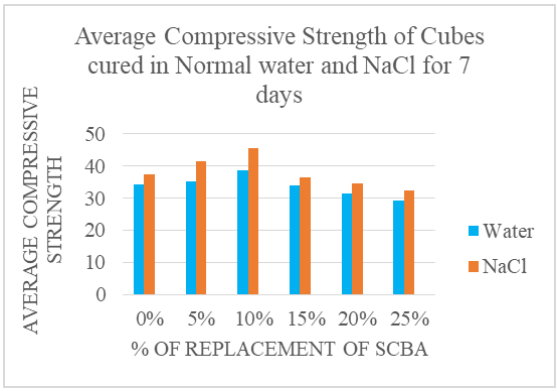

Fig. 3. Average compressive strength of cubes cured in normal water and NaCl Solution for 7 days

Table 5
Compressive strength in normal water

Compressive Strength in Normal Water (Mpa)			
Trial Mix	% SCBA	7 Days	28 Days
NC	0	34.16	48.67
SCBA 1	5	35.19	50.76
SCBA 2	10	38.7	52.7
SCBA 3	15	33.8	44.3
SCBA 4	20	31.43	42.33
SCBA 6	25	29.34	40.33

Table 6
Compressive Strength in 5% NaCl Solution

Compressive Strength in Normal Water (Mpa)			
Trial Mix	% SCBA	7 Days	28 Days
NC	0	37.51	49.16
SCBA 1	5	41.61	50.56
SCBA 2	10	45.56	54.5
SCBA 3	15	36.55	48.3
SCBA 4	20	34.63	46.85
SCBA 6	25	32.36	44.54

Table 7
Variation in Compressive Strength of SCBA Concrete with Nominal Concrete for 28 Days of Water curing

of SCBA	Avg Compressive Strength after 28 days in N/mm^2	Percentage of increase in Strength
5%	50.76	4.11 %
10%	52.7	7.64 %
15%	44.3	_
20%	42.33	_
25%	40.33	_

Note: The Avg Compressive Strength of Nominal Concrete for 28 days under water curing = 48.67 N/mm^2

Table 8
Variation in Compressive Strength of SCBA Concrete with Nominal Concrete for 28 Days of Water curing

% Of SCBA	Avg Compressive strength after 28 days in N/mm^2	Percentage of increase in strength
5%	50.56	2.76 %
10%	54.5	7.9%
15%	48.3	-
20%	46.85	-
25%	44.58	-

Note: The Avg Compressive Strength of Nominal Concrete for 28 days under NaCl curing = 50.16 N/mm^2

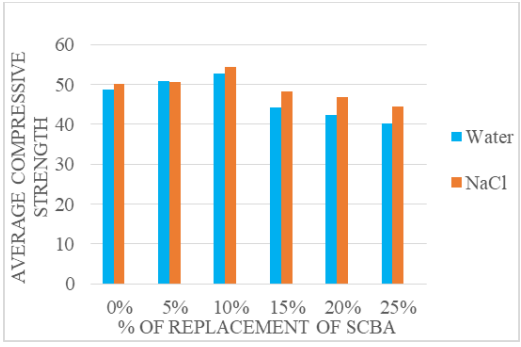

Fig. 4. Average compressive strength of cubes cured in normal water and NaCl Solution for 7 days

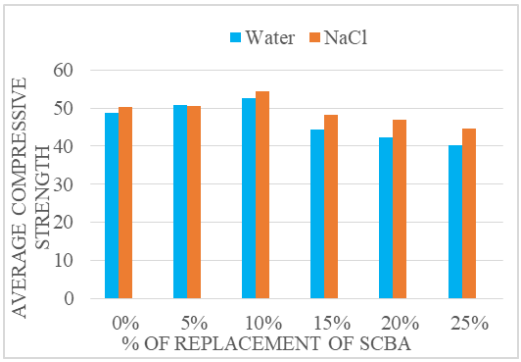

Fig. 5. Average compressive strength of cubes cured in normal water and NaCl Solution for 28 days

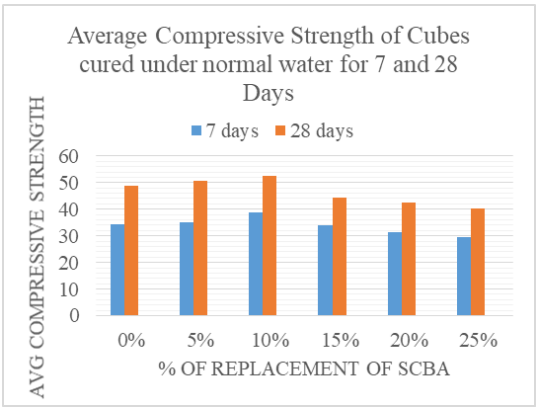

Fig. 6. Average Compressive Strength of cubes for 7 and 28 days cured in Normal Water

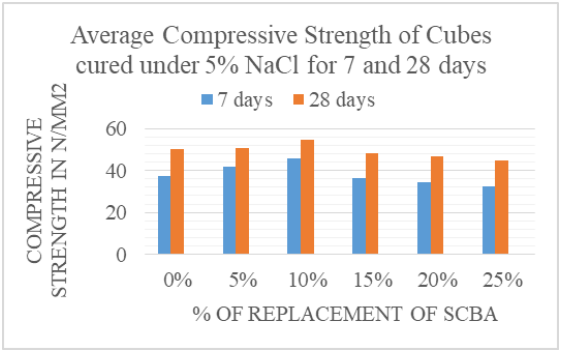

Fig. 7. Average Compressive Strength of cubes for 7 and 28 days cured in 5% NaCl solution

5. Conclusion

- SCBA concrete performed better when compared to ordinary concrete up to 10% replacement of sugarcane bagasse ash when cured in normal water.
- Also, at 10% replacement SCBA Concrete gained maximum strength when cured in NaCl Solution.
- The Compressive strength of Concrete with 5% and 10 % weight replacement of cement with SCBA cured in normal water for 7 days has shown increase in strength at a rate of 2.96 % and 11 % respectively compared to Conventional concrete.
- The Compressive strength of Concrete with 5% and 10 % weight replacement of cement with SCBA cured in normal water for 28 days has shown increase in strength at a rate of 4.11 % and 7.64% respectively compared to Conventional concrete.
- The Compressive strength of concrete with 5% and 10% weight replacement of cement with SCBA cured in NaCl for 28 days has shown increase in strength at a rate of 2.76 % and 7.96 % respectively.
- The compressive strength of concrete cured in Normal water and NaCl solution has shown decreased value for 15 %, 20%, 25 % replacement of SCBA with Cement.
- So the Sugar Cane Bagasse Ash can be advantageously used up to 10 % of replacement with cement.
- Utilization of the waste material Sugar Cane Bagasse ash can be advantageously used as a replacement of cement in the preparation of concrete even when it is exposed to sodium chloride.

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