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Performance Characteristics of Sugarcane Bagasse Ash in Concrete

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Abstract : This paper presents a study on performance characteristics of Sugarcane Bagasse Ash (SCBA) in concrete as cement replacement. India is one of the most agricultural waste producing countries. The researchers all over the global are specializing on different methods for using wastes from agricultural industries as a source of raw materials for construction purpose. By using the wastes, it wouldn't be only of less cost, but also helps environment to free from pollution. The Sugar Cane Bagasse Ash (SCBA) can be partially replaced in cement by 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40%. For the better performance of SCBA. The optimum level 35% of SCBA, and remaining 65% of cement. Various tests are carried out on this concrete to evaluate strength properties such as compressive strength, split tensile strength and durability properties such as sorptivity test. The test results were compared with OPC mix.

KeyWords: Sugarcane bagasse ash, Mechanical Properties, Sorptivity.

1. INTRODUCTION

Concrete is extensively used components for production industry all over international. The increased demand for the manufacturing of cement in concrete leads to environmental pollution huge emission of greenhouse gases. The important reason for carbon footprint is to increases the demand of infrastructure, necessity of production of concrete using naturalmaterials also increased. In order to reduce the amount of CO_2 into the atmosphere the SCM blended concrete should be used. As compared to conventional concrete the blended concrete using SCM have more economic. The utilization of these materials or the combinations of these materials moreover industrial by products like sugarcane bagasse ash, fly ash and other waste materials occupies more percentage of nearby landfill area and main to pollutants problems in those regions. In order to reduce these problems originating from these industrial by-products, from these waste materials there is a need for us to develop profitable building materials. SCBA is industrial waste, which has been produced from sugarcane in India above100 million tons of SCBA is being generated annually. This is huge amount of waste being produced. Due to the pozzolanic property of SCBA, it is being used as partial replacement in cement. Contains alumina and silica. Sugarcane bagasse ash can be a good substitute for construction material. However, the SCBA is an industrial-waste partially replacing by OPC concrete.

The construction industry is undergoing a significant transformation towards sustainability and environmentally responsible practices. In this context, the exploration of alternative materials for concrete production has become an essential avenue for reducing the environmental impact of construction projects. One such material that has garnered attention is sugar cane bagasse, an agricultural residue left behind after sugar extraction. This paper provides a comprehensive introduction to the utilization of sugar cane bagasse in concrete, highlighting its potential as a sustainable construction resource. Sugar cane bagasse has traditionally been considered a waste product of the sugar production industry, often discarded or used as low-value fuel. However, recent efforts to embrace circular economy principles have prompted researchers and practitioners to reconsider its potential. When incorporated into concrete mixtures, sugar cane bagasse offers a range of benefits that align with the global drive for sustainable construction practices.

1. Background and Significance: This section outlines the current challenges facing the construction industry in terms of material sustainability and the urgent need for innovative alternatives. It highlights the importance of sugar cane bagasse as an abundant, renewable resource with untapped potential.

2. Characteristics and Processing: An in-depth exploration of the physical and chemical properties of sugar cane bagasse, including its fibrous nature and composition, is provided. The paper discusses various processing techniques to convert bagasse into usable forms for concrete, such as lightweight aggregates or finely ground powders.

3. Performance and Properties: The impact of sugar cane bagasse on the properties of concrete is a central focus. This section covers aspects such as compressive strength, workability, durability, and thermal insulation. The effects of bagasse on the fresh and hardened properties of concrete are examined.

4. Sustainability and Environmental Benefits: The environmental benefits of incorporating sugar cane bagasse into concrete are thoroughly discussed, including reduced carbon footprint, conservation of natural resources, and lower construction costs. The role of bagasse in promoting sustainability and circular economy principles is emphasized.

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5. Challenges and Considerations: To provide a balanced perspective, this paper also addresses the challenges and considerations associated with using sugar cane bagasse in concrete. It explores potential limitations, such as variations in bagasse quality and the need for adequate testing and quality control.

6. Applications and Future Prospects: The paper concludes by examining the current and potential applications of sugar cane bagasse in concrete, from lightweight construction to thermal insulation. It also discusses future research directions and the prospects for broader adoption in the construction industry.

As the demand for sustainable building materials continues to grow, this paper aims to contribute to the evolving discourse on sugar cane bagasse as a viable and eco-friendly component in concrete. Through an in-depth analysis of its properties, benefits, and challenges, this research provides a valuable resource for architects, engineers, researchers, and policymakers seeking innovative solutions to reduce the environmental impact of construction activities.

2. RESEARCH OBJECTIVES

Optimal amount of SCBA that can be replaced.

To study the impact of SCBA on the strength properties of concrete.

To examine the durability properties of SCBA based blended cement concrete.

3. MATERIALS

3.1 Cement

It is the primary component in production of concrete. Swap the Cement material can be substantially pretentious feature of concrete. The Cement based on this task is OrdinaryPortland Cement of 53 grade.

Table-1: Properties of cement

S. No	Property	Value
1	Specificgravity	3.12
2	Setting time, a) Initial b) Final	 35 min 510 min
3	Fineness test	5%

3.2. Fine Aggregate

The most available component for the manufacture of concrete is fine aggregate. It's been mostly commonly used in the construction purposes; naturally available the river sand is taken into consideration as a fine aggregate. As the river sand is available naturally and it should be free from the materials like organic matter, soil lumps and more. To remove the dirt particles sieving process is done. The fine aggregate taken is taken into consideration passing through 4.75 mm.

S. No	Properties	Value
1.	Specific Gravity	2.84
2.	Fineness modules	7.94
3.	Water absorption	0.05%
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Table-2: Properties of fine aggregate

S. No	Properties	Value
1.	Specific Gravity	2.64
2.	Density (kg/m^3)	1680
3.	Zone	II
4	Fineness modulus	2.64

3.3. Coarse Aggregate

These are a huge category particulate non-reactive material which is used in manufacturing of concrete. Semi-precious stones are overwhelmed to the required size and used as coarse aggregate. An aggregate of substantially the same most nominal size and the equal grain size will produce high-quality workability concrete. These aggregates are bonded collectively by using the cement and fine aggregate within the presence of water to shape concrete.

Table-3: Properties of Coarse Aggregate

S. No	Properties	Value
1.	Specific Gravity	2.84
2.	Fineness modules	7.94
3.	Water absorption	0.05%

3.4 Sugarcane Bagasse Ash

Sugarcane bagasse to produce steam energy to spin turbines they are burnt in cogeneration boilers. The left-over ashes that are obtained from cogeneration boilers are generally termed as sugarcane bagasse ash. The particles of shape prismatic and spherical are considered to have the rich silica content in it when in comparison to fibrous particles. Those fibrous particles are constructed from carbon in it. However, the SCBA after processing the particle size <=19 microns then it can be used as substitute for cement.

Table-4: Properties of Sugarcane Bagasse Ash

Properties of SCBA	
Form	Fine powder
Color	Gray
Specific Gravity	2.07
Particle size	<=19microns
SiO_2	64.15%

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4. MIX DESIGN

Concrete mix of M40 grade. Cement was substitute with sugarcane bagasse ash by 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40%.

Table -5: Mix proportion

w/c ratio (kg/m³)	Cement (kg/m³)	Fine Aggregate (kg/m³)	Coarse Aggregate (kg/m³)
186	492.9	651.966	1135.716
0.4	1	1.323	2.304

5. TESTS OF SPECIMEN

5.1 Compressive Strength Tests

Cubes of size 150 × 150 × 150 mm were casted and tested in compression testing machine. Capacity of machine is 400 Tons.

Table -6: Compressive strength of SCBA at 3, 7, 28 days

Mix	Percentage Replacement in Cement		Compressive Strength(N/mm^2)		
	Cement	SCBA	3 Days	7 Days	28 Days
1	100%	0%	23.8	35.6	51
2	95%	5%	27	40	52.18
3	90%	10%	28.06	41.64	53
4	85%	15%	29	42.38	53.7
5	80%	20%	29.8	43.6	54.04
6	75%	25%	30.7	44	54.87
7	70%	30%	31.5	46.1	56.9
8	65%	35%	33.66	47.8	57.64
9	60%	40%	30.7	44.6	54.1

Graph 1: Compressive strength at 3, 7, 28days for partial replacement of cement with SCBA

5.2 Split Tensile Strength Tests

Table-7: Split tensile strength of SCBA at 3, 7, 28 days

Mix	Percentage Replacement in Cement		Split Tensile Strength (N/Mm^2)		
	Cement	SCBA	3 Days	7 Days	28 Days
1	100%	0%	1.35	1.59	2.01
2	95%	5%	1.39	1.61	2.07
3	90%	10%	1.4	1.69	2.1
4	85%	15%	1.46	1.75	2.15
5	80%	20%	1.49	1.8	2.23
6	75%	25%	1.5	1.89	2.26
7	70%	30%	1.53	1.9	2.3
8	65%	35%	1.55	1.96	2.35
9	60%	40%	1.2	1.6	1.9

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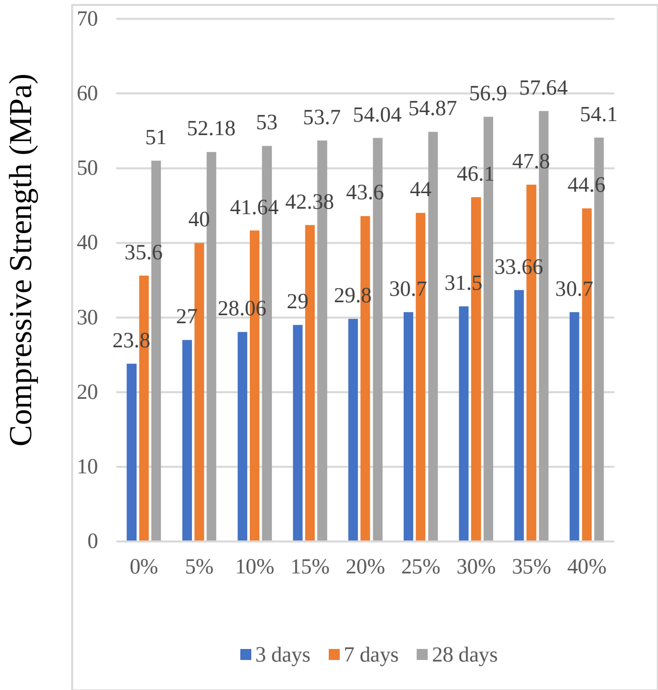

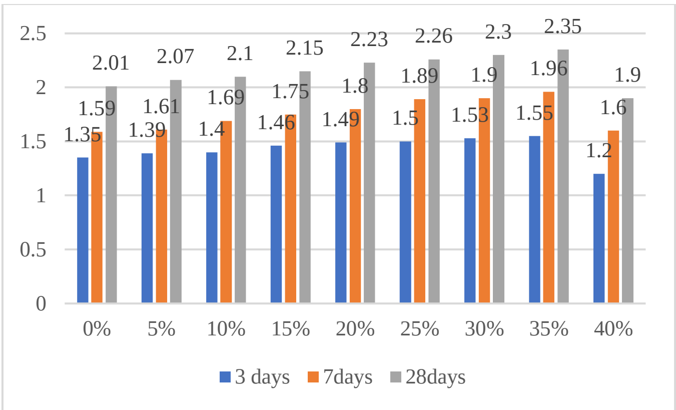

Graph 2: Split Tensile strength at 3, 7, 28days for partial replacement of cement with SCBA

5.3 Sorptivity Tests

Test specimens for compressive strength and change in mass test were 150 x 150 x 150 mm cubes are casted each. The sorptivity of concrete can be regarded as a measure of the capillary forces exerted by the structure of pores that cause the suction of liquids in the concrete. Cubes were immersed in water for 28 and56days of curing period for a specific exposure period. In the initial observation 6 hrs. The regression coefficient is below 1 is the good concrete.

Table-8: Sorptivity values of SCBA for 28 days

TIME (S^1/2)	OPC (mm)	SCBA 5% (mm)	SCBA 10% (mm)	SCBA 15% (mm)	SCBA 20% (mm)	SCBA 25% (mm)	SCBA 30% (mm)	SCBA 35% (mm)	SCBA 40% (mm)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	1.1	1.1	1.1	1.1	1.4	0.4	0.5	1.8	0.9
11.0	1.5	1.2	1.2	1.3	1.5	0.7	1.0	2.0	1.3
17.0	1.8	1.9	1.9	2.0	1.9	0.9	1.3	2.3	1.6
24.0	2.0	2.0	2.0	2.2	2.0	1.1	1.6	3.0	1.8
35.0	2.5	2.1	2.0	2.7	2.7	1.3	2.0	3.8	2.0
42.0	2.7	2.3	2.4	3.1	3.0	1.6	2.1	4.6	2.3
60.0	3.1	2.5	2.6	3.6	3.7	1.8	2.6	5.1	2.7
85.0	3.5	2.5	3.1	4.0	4.1	2.0	3.1	6.4	3.1
104.0	4.0	3.0	3.3	4.5	4.8	2.4	3.2	7.9	3.3
120.0	4.2	3.1	3.5	4.9	5.6	4.6	3.9	9.1	3.6
134.0	4.6	3.3	3.6	5.3	5.9	6.3	4.2	11.5	3.8
147.0	4.6	3.9	3.9	5.5	9.0	7.8	6.3	13.7	4.0
294.0	7.6	4.2	4.9	9.1	10.6	8.2	7.3	15.0	6.8
416.0	9.6	4.7	6.2	10.7	11.1	9.0	8.0	16.8	8.0
509.0	10.4	5.0	7.4	11.7	13.6	11.4	8.6	17.2	8.8
588.0	12.0	6.3	8.9	13.1	14.3	12.6	9.0	17.8	9.6
657.0	12.4	7.8	9.3	14.0	14.9	13.3	11.2	18.2	10.5
720.0	12.9	9.1	11.2	14.2	15.6	14.8	13.2	18.6	11.2
778.0	13.2	10.1	13.1	14.7	15.9	15.7	15.6	19.1	11.5
831.0	13.3	11.3	14.0	15.0	16.3	16.9	17.2	19.4	11.8

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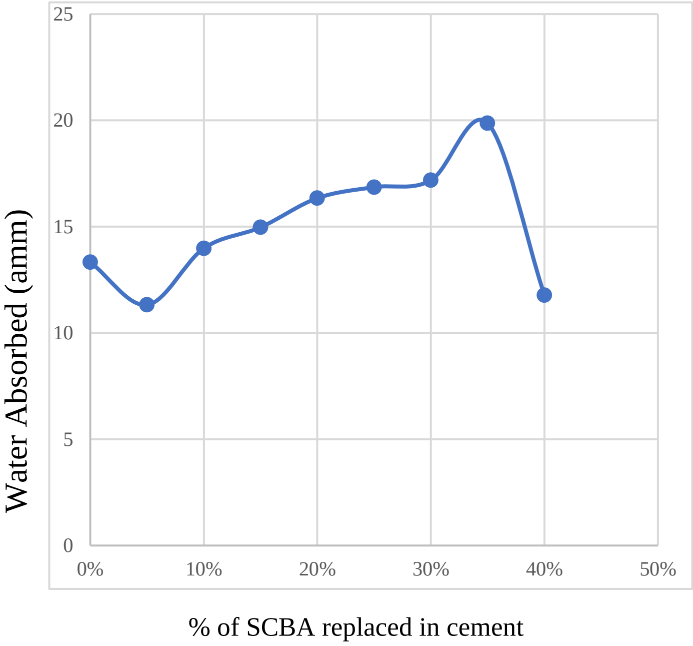
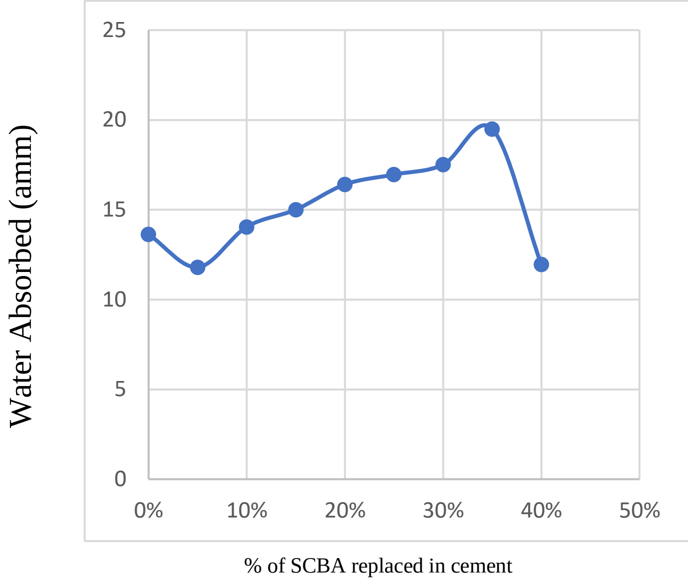


Graph 3: Sorptivity test at 28 days and for partial replacement of cement with SCBA

Table-9: Sorptivity values of SCBA for 56 days

TIME (S^1/2)	OPC (mm)	SCBA 5% (mm)	SCBA 10% (mm)	SCBA 15% (mm)	SCBA 20% (mm)	SCBA 25% (mm)	SCBA 30% (mm)	SCBA 35% (mm)	SCBA 40% (mm)
0	0	0	0	0	0	0	0	0	0
8	1.4	1.05	1.1	1.2	1.35	1.44	1.46	1.8	0.88
11	1.59	1.68	1.63	1.39	1.5	1.66	1.5	2.01	1.36
17	1.78	1.9	1.95	2	1.84	1.89	2	2.4	1.53
24	2.3	2	2.15	2.27	2.2	2.12	2.55	3	1.79
35	2.59	2.19	2.32	2.61	2.65	2.33	2.61	3.81	2
42	2.75	2.35	2.49	3.18	2.98	3.55	3.1	4.96	2.34
60	3.5	2.48	2.62	3.35	3.68	3.77	3.5	5.2	2.67
85	3.98	2.57	3.19	4.05	4.12	4.22	5.11	6.8	3.11
104	4.05	3	3.39	4.4	4.78	5.44	6.23	7.96	3.34
120	4.37	3.19	3.48	4.89	5.62	6.6	6.86	9.52	3.5
134	4.65	3.26	3.56	5.36	5.86	7.34	7.15	11.4	3.71
147	4.69	3.9	3.98	5.5	8.98	8.81	8.31	13.8	4.8
294	7.95	4.46	4.95	9.5	10.8	9.23	9.34	15.0	6.81
416	9.8	4.71	6.21	10.6	11.5	9.98	9.89	16.8	8
509	10.9	5.5	7.38	11.9	13.6	11.8	11.5	17.1	8.78
588	12.2	6.8	9.01	13.6	14.3	12.7	13.2	17.7	9.59
657	12.6	7.9	9.63	14	14.8	13.5	11.2	18.2	10.5
720	12.9	9.54	11.6	14.3	15.6	14.5	14.1	18.6	11.1
778	13.3	10.3	13.4	14.9	15.9	15.7	15.9	19.1	11.5
831	13.4	11.8	14.0	15.0	16.4	16.9	17.5	19.5	11.9



Graph 4: Sorptivity test at 56 days and for partial replacement of cement with SCBA

6. RESULTS AND DISCUSSION

Above experimental analysis shows that results at age of 3-, 7- and 28-days compressive strength, split tensile strength are maximum. For sorptivity test at the age of 28 and 56 days, durability increases as SCBA percentage increases. Further increase of SCBA, strength and durability reduced. Maximum strength obtained at 35% substitute of SCBA in cement.

7. CONCLUSIONS

- SCBA used as qualified substitute for cement up to 35%. More than 35%, SCBA act only as a filling material.
- Results shows that concrete at 35% SCBA as cement for 3, 7, 28 days curing gives greatest strength and sorptivity test at the age of 28, 56 days curing gives greatest durability.
- The compressive strength increased 6.64%, split tensile strength increased 0.34%, durability increased 6.07% with replacement of SCBA in cement when compared to control mix.
- By utilizing of waste materials in construction works reduces pollution also.
- The influence of substitute materials in the strength point of view was more in compared OPC mix.

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