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Replacement of Cement by Bagasse Ash in Cement Concrete

Shaikh Musharraf
P.G. Student
Dept. of Civil Engineering
PES College of Engineering, Aurangabad
skmusharraf1392@gmail.com

Dr. Abhijeet Wadekar
Professor
Dept. of Civil Engineering
PES College of Engineering, Aurangabad
apwadekar@gmail.com

Dr. Deepak N. Kakade
Professor
Dept. of Civil Engineering
PES College of Engineering, Aurangabad
deepak.kak06@gmail.com

ABSTRACT

OPC is the most extensively used construction material in the world. Since the early 1980's, there has been an enormous demand for the mineral admixture and in future this demand is expected to increase even more. If some of raw material having similar composition can be replaced by weight of cement in concrete then cost could be reduced without affecting its quality. After the extraction of all economical sugar from, about 40-45 percent fibrous residue is obtained, which is reused in the same industry as fuel in boilers for heat or power generation leaving behind 8 -10 percent ash as waste, known as bagasse ash (SCBA). For this reason, sugarcane bagasse ash (SCBA) is one of the main by-products can be used as mineral admixture due to its high content in silica (SiO2). In this paper, cement has been partially replaced in percentage of 0, 15%, 20%, 25%, 30%,35% by sugarcane bagasse. many tests like tensile strength test, compressive strength test specific gravity test etc. were undertaken. The result shows that bagasse ash can be a suitable replacement to cement up to 30%.

General Terms

Bagasse Ash, SCBA, Concrete

Keywords

Bagasse Ash, Sugarcane Bagasse Ash, SCBA

1. INTRODUCTION

Till this day, ordinary Portland cement (OPC) retains its popularity as the construction material of choice in the field of civil engineering. The global production of cement has exceeded 3.6 billion tones in meeting mankind's thirst for urbanization that involves construction of buildings and infrastructure, especially in fast developing countries such as China and India. Cement is the principal binder holding the aggregates together to produce concrete in the presence of water for hydration. As an engineered material, concrete composites are desired for their excellent compressive strength.

Sugarcane is an important food crop for tropic sand sub tropics. It is the major raw materials used for sugar production. Sugarcane bagasse (SCB) is the waste produce

after juice extraction from sugarcane. The Sugarcane bagasse ash (SCBA) is obtained as by product of control burning of sugarcane bagasse. SCBA constitutes an environmental nuisance as they form refuse heaps in areas they are disposed. Sugarcane production in India is over 300 million tons/year leaving about 10 million tons of as unutilized and, hence, wastes material. This paper analyses the effect of SCBA in concrete by partial replacement of cement at the ratio of 0%, 15%, 20%, 25% ,30% and 35% by weight. The main ingredients consist of Portland cement, SCBA, crushed sand, coarse aggregate and water. After mixing, concrete specimens were casted and subsequently all test specimens were cured in water at 7 & 28Days. The present study was carried out on SCBA obtained by controlled combustion of sugarcane bagasse, which was procured from the Maharashtra in India.

2. OBJECTIVES OF STUDY

To study by what percentage of cement can be replaced with sugarcane bagasse ash and to study the changes in mechanical properties of concrete with the partial replacement of cement with sugarcane bagasse ash for various percentages

3. PHYSICAL AND CHEMICAL PROPERTIES OF SCBA AND OPC-

In this paper firstly the required chemical and physical properties of sugarcane bagasse ash and ordinary Portland cement (OPC) are calculated.

Chemical properties							
Chemical Composition (Wt.%)							
Compare	SiO_2	AL_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O
SCBA	78.3	8.55	3.61	2.15	0.12	3.5	0.13
OPC	18.4	5.6	3	66.8	1.4	2.8	0.5

Physical properties			
Density	Blaine Surface Area	Particle Size	Colour
G/Cm^3	Cm^2/G	Um	
2.52	5140	28.9	Black
3.15	3250	36.2	Dark grey

MATERIALS USED

1.CEMENT (JAYPEE CEMENT OPC 53 GRADE).

Chemical Test Results:

Test Report

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A	Chemical Analysis			
Sr. No.	**Test Carried Out**	**Result Obtained**	**Requirement of OPC 53gr is-12269:2013**	**Test Reference**
1	Total LOI (%by mass)	1.09	Max 4.0	IS-4032-1985
2	Insoluble residue (%by mass)	0.73	Max4.0	IS-4032-1985
3	Sulphuric anhydride (%by mass)	1.82	Max 3.5	IS-4032-1985/IS 12803-1989
4	Magnesia (%by mass)	1.16	Max 6.0	IS-4032-1985/IS 12803-1989
5	Chloride (%by mass)	0.04	Max 0.1 for n.c Max 0.1 for p.c	IS-12423/IS-23803/1989

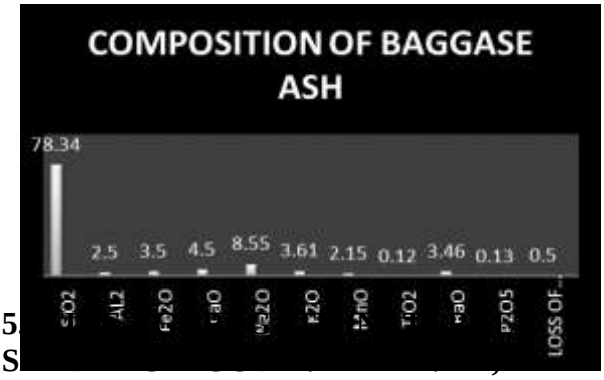
Physical Test

B	Physical Analysis			
Sr. No.	**Test Carried Out**	**Result Obtained**	**Requirement of OPC 53gr is-12269:2013**	**Test Reference**
1	Fineness (m^3/kg)	297	Min.225	IS: 4031 (Part 2) 1999 (Reaffirmed in 2004)
2	Consistency (%)	30		IS: 4031 (Part 4) 1988 (Reaffirmed in 2005)
3	Setting time (minutes)			IS: 4031 (Part 5) 1988 (Reaffirmed in 2005
a.	Initial	125	Min.30	
b.	Final	185	Min.600	
4	Soundness	0.03	Max 0.8	IS: 4031 (Part 3) 1988 (Reaffirmed in 2005
5	Compressive Strength (Mpa)			IS: 4031 (Part 6) 1988 (Reaffirmed in 2005)
a.	At 168±2h (7 days)	49.93	Min 37	
b.	At 672±4h (28 days)	65.2	Min.53	

4. BAGGASE ASH:

Baramati Agro Sugar Factory, Kannad, District Aurangabad (M.S.). (sample-100gm)Sugarcane Bagasse Ash (SCBA) is one of the main byproducts can be used as mineral admixture due to its high content in silica (SiO2). 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 and we got the material from KANNAD.

Sr. No	Test Carried Out	Result Obtained
1	Fineness (%)	20%
2	Specific Gravity	1.89



5 S PAITHAN) (SAMPLE- 5KG)

SR.NO	TEST CARRIED OUT	RESULT
1	FINENESS MODULUS	3.36 (zone 1 type)
2	SPECIFIC GRAVITY	2.68
3	SILT CONTENT	6% by volume

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The fineness modulus (FM) of fine aggregate (sand) was found to be 3.36. Hence as per IS: 383 – 1970, the sand is of Zone I type. The average silt content of fine aggregate (sand) was found to be 6%byvolume of sample. Thus, the obtained value is less than 8% by volume of sample. Hence asper IS: 383 – 1970, the sand is suitable for concreting.

6. MIX DESIGN

Summary of mix design									
Tri	% Bagasse ash	Bagasse ash in Kg	Mix						
			Summary of mix design						
			Water	Cement	N. Sand	10mm	20mm	Admix.	Slump
			kg	kg	kg	kg	kg	%	mm
1	0%	0	188	395	709	507	766	3.95	110
2	15%	65	187	369	678	484	732	4.34	90
3	20%	87	187	347	678	484	732	4.34	100
4	25%	108	187	326	678	484	732	4.77	90
5	30%	130	187	304	678	484	732	6.08	100
6	35%	152	187	282	678	484	732	7.38	80

7. COARSE AGGREGATE (CRUSHED, WELL GRADED AGGREGATE FROM BLACK TRAP BASALT OF SIZE 10mm AND 20mm) (SAMPLE-1000gm)

SR. NO	TEST CARRIED OUT	RESULT
1	FINENESS MODULUS	2.9
2	SPECIFIC GRAVITY (10mm)	2.89
3	SPECIFIC GRAVITY (20mm)	2.91
4	ELONGATION INDEX (10mm)	20.79%
5	ELONGATION INDEX (20mm)	20.64%
6	FLAKINESS INDEX (10mm)	19.25%
7	FLAKINESS INDEX (20mm)	19.11%
8	AGGREGATE CRUSHING VALUE (10mm)	20%
9	AGGREGATE CRUSHING VALUE (20mm)	16.20%

From the above values of tests all the materials are suitable for use.

8. PROPERTIES OF SUPER PLASTICIZER

Sulphonated Naphthalene Formaldehyde Polymers based super plasticizer is used, which confirming the specification of IS 9103 – 1999. The super plasticizer is of the brand

Sika India Pvt. Ltd. having product name as Choksey – 610 DOSE- 1%-1.7%. The properties of S.P as stated by manufacturer are presented in Table

Sr. No.	Properties	Details
1	Appearance / Colour	Brown Liquid
2	Chemical Base	Modified Naphthalene Formaldehyde Sulphonate
3	Relative Density	~ 1.20 kg/l at 30°C
4	pH value	Min 6
5	Chloride content	0.2% Max.
6	Air entrainment	Nil
7	Nitrate content	Nil

9. RESULTS

9.1 Workability

Sr. No.	Mix Design	w/c	Percentage of Bagasse Ash	Percentage of Super Plasticizer	Slump mm
1	2	3	4	5	6
1	M40	0.4	0%	1%	110
2	M40		15%	1%	90
3	M40		20%	1.20%	100
4	M40		25%	1.40%	90
5	M40		30%	1.50%	100
6	M40		35%	1.70%	80

9.2 Compressive Strength (7 Days)

% REPLACEMENT OF CEMENT	COMPRESSION STRENGTH (N/MM)
0%	41.92
15%	42.81
20%	33.62
25%	31.7
30%	30.66
35%	27.99

9.3 Compressive Strength (28 Days)

% REPLACEMENT OF CEMENT	COMPRESSION STRENGTH (N/MM)
0%	52.29
15%	52.14
20%	48.56
25%	48.1

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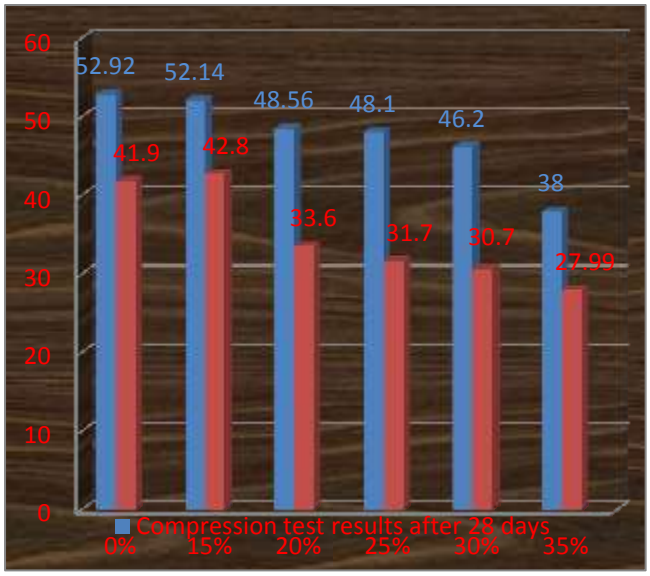
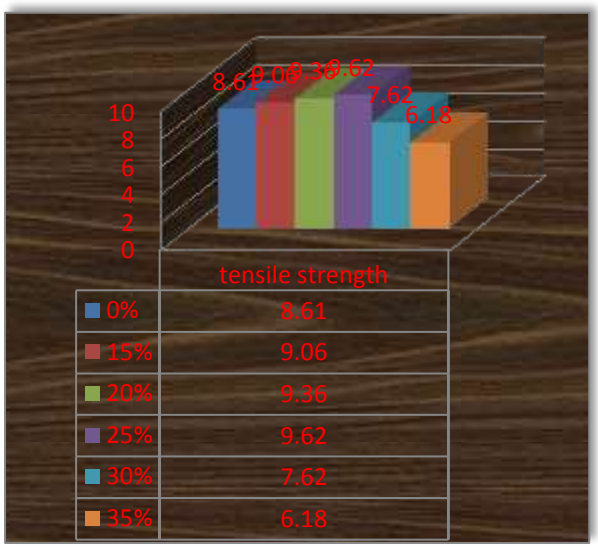
30%	46.6
35%	38

9.4 Graphical Representation For Compressive Strength

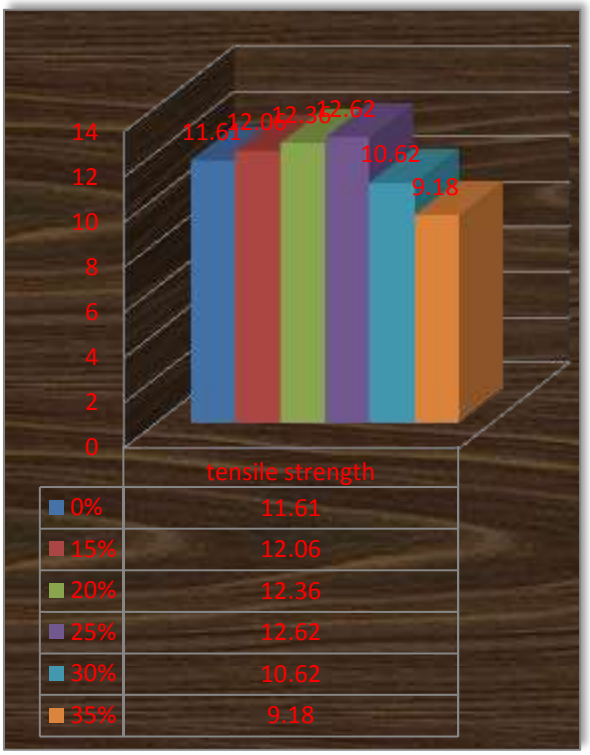


From the above results, it is seen that the compressive strength of concrete after replacement of cement by sugarcane bagasse ash goes on decreasing with the increase in percentage of sugarcane bagasse. It is also observed that up to 30% replacement the required strength is achieved but after 30% the strength achieved is less than required hence not preferred.

9.5 Graphical Representation For Tensile Strength For 7 Days



9.6 Graphical Representation For Tensile Strength For 28 Days



From the above results it is observed that up to 30% strength is increased. Hence replacement above 30% should not be preferred.

9.7 Economy Achieved

SR . NO	% OF CEMENT REPLACEMENT	ECONOMY ACHIEVED IN KG'S	ECONOMY ACHIEVED IN RS.
1	0%	-	-
2	15%	26	156
3	20%	48	288
4	20%	69	414
5	25%	91	546
6	30%	113	678

CONCLUSIONS

The calculated target mean strength of 48.25 N/mm2was not achieved. But we are nearer to it as by 30% replacement of OPC we have 46.20 N/mm2 strength on 28 day's testing.

- It is found that the cement could be advantageously replaced with SCBA up to maximum limit of 30% For M40 Grade of concrete as our target strength was achieved.
- Partial replacement of cement by SCBA increases Water demand of fresh concrete; therefore, use of super plasticizer is essential.

- This can be used for plain and reinforced concrete. As 0% to 30%replacement can be used for reinforced concrete with normal aggregates.
- The compressive strength of the concrete cubes for all the mix ratios increases with curing age and decreases as the SCBA content increases. The percentage reduction of compressive strength for 0%, 15% ,20%, 25%, 30% & 35% replacement of cement with SCBA compared with control are 108.37%, 108.06%, 100.64%, 99.69%, 95.75% & 78.76% respectively.
- The tensile strength of concrete cubes in replacement of 15%, 20%, 25%, 30% and 35% of cement with SCBA are 11.61 N/mm^2 ,12.06 N/mm^2 ,12.36 N/mm^2, 12.62 N/mm^2, 10.62 N/mm^2, 9.18N/mm^2 respectively.
- From the density result, the SCBA concrete can be classified as normal weight concrete. From the economy point of view the replacement of 15%, 20%, 25%, 30% and 35% of cement with SCBA an economy achieved were 26 Kg, 48 kg, 69 kg, 91 kg, 113 kg of cement respectively.
- It was clearly shown that SCBA is a pozzolanic material that has the potential to be used as partial cement replacement material and can contribute to the environmental sustainability also This could reduce the environmental problems and minimize the requirement of land fill area to dispose SCBA.
- Water requirement increased as the percentage of SCBA increased. Unit weight of the mixture produced decreased as the percentage of SCBA increased.
- Workability of the mixtures depended primarily on the percentage of SCBA used. This is consistent with the porous nature of BA particles where by a greater surface area and larger average particle size serve to enhance absorption of water.
- The compressive strength results represent that the strength of the mixes with 15%, 20%, 25%, 30% and 35% SCBA increased at later days (28 days) as compared to Earlier days (7 days) that may be due to pozzolanic properties of SCBA. The greatest compressive strength, split tensile strength and flexural strength were achieved with the water cement ratio of 0.40.

RECOMMENDATIONS:

SCBA is a pozzolana and can be recommended for use as partial replacement of cement in concrete production at a percentage up to 30 %. For environmental sustainability, SCBA can be utilized for the production of lightweight, durable and cheap concrete. Since it is available in significant quantities across the country.

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About Authors

Mr. Shaikh Musharraf[1], P.G. Student, PES college of Engineering Aurangabad.

Dr. Abhijeet Wadekar[2] Received his Ph.D. in structures in 2010. He is currently working as Principal, PES college of Engineering, Aurangabad from Jan 2011.

Dr. Deepak N. Kakade[3], Received his Ph.D. in structures in 2017-18. He is currently working as Professor, PES college of Engineering, Aurangabad.