Application of Sugarcane Bagasse Ash as Replacement of Cement Specifying Various Properties of Concrete

Amit R. Nishad, Rahul R. Patle, Ariba K. Hamidi, Mangesh Urade

Abstract: ***Sugarcane bagasse ash is a by-product of sugar factories found after burning of sugarcane bagasse which itself is an extracted material. India alone generates approximately 90 million of bagasse as a solid waste from the sugarcane industry every year. The disposal of this material is already causing environmental problems around due to unavailability of sufficient land for disposal. About 3 tones out of 10 tones sugarcane crushed is the ash obtain after burning. This accumulation of waste is not only causing problem for disposal but also affect the environment adversely. It becomes necessary to find the solution for disposal of sugarcane bagasse ash. In this paper bagasse ash sample was collected from Purti Power plant (Bela) which was sieved through 125 micron IS sieve size. Ordinary Portland Cement was replaced by the bagasse ash sample in the percentage of 0%, 10%, 20% and 30% for M25 mix. The properties of concrete such as workability i.e. slump cone and compaction factor test, compressive strength along with the test on bagasse ash individually such as moisture content, volatile matter, carbon content, consistency test, initial and final setting time were tested. The cubes casted for compressive strength result were tested for 7 days, 14 days as well 28 days of tank curing. The outcomes in the test signifies that it will be beneficial to use the sugarcane bagasse ash as a replacing material of cement up to 20% of its replacement.***

Keywords: Bagasse Ash, Compressive Strength, Replacement of Cement, Properties of Concrete, Ordinary Portland Cement

I. INTRODUCTION

Sugarcane bagasse ash is a by-product of sugar factories found after burning of sugarcane bagasse which itself is found after the extraction of all economical sugar from sugarcane in large quantity. The disposal of this material is already causing environmental problems around the sugar factories as well as shortage of disposal land. For each ten tons of sugarcane crushed, a sugar factory produces nearly three tones wet bagasse ash. When bagasse waste is burned under the controlled manner it also gives ash having amorphous silica, which has pozzolanic properties which will enhance the properties of cement in concrete. After combustion yields ashes containing high amounts of unburned matter like silica and alumina oxides. Sugarcane bagasse ash used as cement replacement material to improve and enhance quality and reduce the quantity of cement.

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India alone generates approximately 90 million of bagasse as a solid waste from the sugarcane industry per year. Disposal of solid waste generated from industrial production activity is the other serious problem which is need to be figure out the solution of it. The accumulation of wastes is not only a burden to the industry causing disposal problem, but also affects the environment adversely.

Ordinary Portland cement is the most extensively used construction material in the world. Now a day, every structure has its own intended purpose and hence to meet this purpose modification in traditional cement concrete which has become essential. This situation has led to the extensive research on concrete resulting in mineral admixture to be partly used as cement replacement to increase workability in most structural application. 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 and properties of cement will also change. 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 during construction work.

The present study was carried out on SCBA obtained by controlled combustion of sugarcane bagasse, which was procured from the Maharashtra in India. This paper analyses the effect of SCBA in concrete by partial replacement of cement at the ratio of 0%, 10%, 20%, and 30% by weight. The main ingredients consist of Portland cement, SCBA, crushed sand, coarse aggregate and water. After mixing, concrete specimens will be casted and subsequently all test specimens will be cured in water at 7, 14 and 28 days. The properties of concrete such as workability i.e. slump cone and compaction factor test, compressive strength along with the test on bagasse ash individually such as moisture content, volatile matter, carbon content, consistency test, initial and final setting time will be tested.

II. OBJECTIVES OF STUDY

The main objective of this research was to determine the effectiveness of sugarcane bagasse ash (SCBA) as cement replacement material in concrete. To study the different strength of hardened concrete such as compressive strength of concrete cubes at 7 days, 14 days and 28 days. To determine reliability of bagasse ash by testing other properties of bagasse ash such as setting time, carbon content, workability etc. To increases the usage of waste product for the purpose of commercial work. To control the adverse effect of pollution because of disposal of waste (bagasse ash).

III. LITERATURE REVIEW

Many researchers from various countries have made experimentation in utilizing the SCBA as replacement materials in concrete mostly replacing cement and few on fine aggregate.

R. Shrinivasan and K. Sathiya (2010) studied on "Experimental Study on Bagasse Ash in Concrete". The utilization of industrial and agricultural waste produced by industrial processes has been the focus of waste reduction in research for economic, environmental, and technical reasons. Sugar-cane bagasse is a fibrous waste product of the sugar refining industry, along with ethanol vapor and molasses. This waste product (Sugar-cane Bagasse ash) is already causing serious environmental pollution to nearby deposition, which calls for urgent ways of handling the waste. Bagasse ash mainly contains aluminum ion and silica content in it. 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 hardened concrete tests like compressive strength were also performed, split tensile strength, flexural strength and modulus of elasticity at the age of seven and 28 days was obtained. The test result indicate that the strength of concrete increase up to 15% SCBA replacement with cement.

Piyush kumar & Anil Pratap Singh (2015) studied on "Effect of use of Bagasse Ash on Strength of Concrete", with increasing demand and consumption of cement, researchers and scientist are in search of developing alternate binders that are ecofriendly and contributes towards waste management. In this paper SCBA has been chemically and physically characterized and partially replaced in the ratio of 0%, 5%, 10%, 15% & 20% by weight of cement in concrete.

Sagar W. Dhengare, Dr. S.P. Raut, N.V. Bandwal, Anand Khangan (2015) Studied on, "Investigation into Utilization of Sugarcane Bagasse Ash as Supplementary Cementations Material in Concrete". The paper presented here is for the use of sugarcane bagasse ash (SCBA) as a pozzolanic material for producing high-strength concrete. The utilization of agricultural waste as well as industrial waste produced by industrial processes has been the focus on waste reduction. Ordinary Portland cement (OPC) is partially replaced with finely sugarcane bagasse ash. The concrete mixtures, in part, are replaced with 0%, 10%, 15%, 20%, 25% and 30% of SCBA respectively. In addition, the compressive strength, the flexural strength, the split tensile tests were determined. The bagasse ash was sieved through No. 600 sieve. The mix design used for making the concrete specimens was based on previous research work from literature. The water –cement ratios varied from 0.44 to 0.63. The tests were performed at 7, 28, 56 and 90 days of age in order to evaluate the effects of the addition SCBA on the concrete. The test result indicate that the strength of concrete increase up to 15% SCBA replacement with cement.

Jaymin Kumar, A. Patel, Dr. D. B. Raijiwala (2015) studied on, "Experimental Study on Use of Sugar Cane Bagasse Ash in Concrete by Partially Replacement with Cement". In this paper sugar cane bagasse ash which is taken from one of the sugar mill of south Gujarat (INDIA) used in M25 grade of concrete by replacing cement 5% by weight and compare with normal M25 grade of concrete to check the feasibility of sugar cane bagasse ash in concrete.

S. Praveen kumar, J Shanmuga sundaram and B Samynathan Department of Civil Engineering (2017), studied on, "Effect of Bagasse Ash in Properties of Cement Paste and Mortar". They concluded that the setting time increases with increase in bagasse ash content in cement mortar. It that initial setting time for control specimen was 60 min while for 30% replacement was 100 min. The final setting time for control specimen was 240 min and for 30% replacement was 310 min. It is inferred that change of state is prolonged due to large surface area and enhanced pozzolanic reactivity of bagasse ash.

Brian Mwendwa, Dr. Timothy Nyomboi, and Raphael Ndisya Mutuku studied on "Consistency, Setting Times and Chemical Properties of Sugar Cane Bagasse Ash Cement". The result obtained shows the initial and final setting times behavior of SCBA. From the results, it is noted that the initial and final setting times for Sugar Cane Bagasse Ash Cement, the initial setting times for SCBAC with 0%, 5%, 10%, 15% and 20% SCBA are 2.25 hours, 2.67 hours, 2.83 hours, 3.08 hours and 3.42 hours respectively. Also, the final setting times for SCBAC with 0%, 5%, 10%, 15% and 20% SCBA are 8.33 hours, 7.92 hours, 7.83 hours, 7.58 hours and 7.5 hours respectively.

Srinivasan et al., studied chemical and physical characterization of SCBA, and partially replaced in the ratio of 0%, 5%, 15% and 25% by weight of cement in concrete. Compressive strength, split tensile strength, flexural strength and modulus of elasticity at the age of 7 and 28 days was obtained as per Indian Standards. It was found that the cement could be advantageously replaced with SCBA up to a maximum limit of 10%. 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 concrete.

IV. EXPERIMENTAL INVESTIGATION

Material Used:

4.1 Cement- Ordinary Portland cement of 53 grade from a single batch was used for the entire work and care has been taken that it has to been stored in airtight containers to prevent it from being affected by the atmospheric and monsoon moisture and humidity. The cement procured was tested for physical requirements in accordance with IS: 12269-1987 and for chemical requirements in accordance with IS: 4032-1977.

4.2 Water- Mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportions. In this project clean potable water is used and curing as per IS: 456-2000.

4.3 Fine Aggregate- The river sand, passing through 4.75 mm sieve and retained on 600 μm sieve, conforming to Zone II as per IS 383-1970 was used as fine aggregate in the present study.

The sand is free from clay, silt and organic impurities. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk modulus in accordance with IS: 2386-1963.

4.4 Coarse aggregate: The course aggregate used in this present study is 20 mm and 10 mm down size locally available crushed stone obtained from local quarries. The physical properties have been determined as per IS: 2386-1963.

4.5 Sugarcane Bagasse Ash- Sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses 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 from Purti Power Plant (BELA), Nagpur.

Fig. No. 3.5: Sugar Bagasse ash

Table No. 3.5: Chemical Properties of Sugarcane Bagasse Ash Powder

Description of Properties	Percentage (%)
Silica (SiO_2)	66.89
Alumina (Al_2O_3)	29.18
Ferric oxide (Fe_2O_3)	29.18
Calcium Oxide (CaO)	1.92
Magnesium Oxide (MgO)	0.83
Sulphur tri Oxide (SO_3)	0.56
Loss of Ignition	0.72
Chloride	-

V. TEST PERFORMED

The tests have been performed to determine the mechanical properties were compressive strength of sugarcane Bagasse Ash replaced by the cement.

5.1. Consistency test:-The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the **IS: 4031 (Part 4) – 1988.**

5.2. Initial and final setting time:- IS: 4031- (part 5) - 1988. By using Vicat apparatus, we have done initial setting time for different % of bagasse ash in cement.

5.3. Weighing 400gm cement to perform test.

Water is used of determined consistency which kept constant throughout the segment etc.

5.4. Slump cone test: - IS code used for determining slump of concrete is **IS: 1199 - 1959**. Compressive test were carried out for bagasse ash replacement, addition of admixture as well as both combination in concrete. This test were performed to know the high workability of concrete.

5.5. Compaction Factor test: - IS code used for determining compaction factor of concrete is **IS: 1199 - 1959.** Compressive test were carried out for bagasse ash replacement, addition of admixture as well as both combination in concrete. This test were performed to know the low workability of concrete.

5.6. Compressive strength test for concrete: - IS code used for determining fineness is **IS: 516-1959**. Compressive test were carried out for bagasse ash replacement, addition of admixture as well as both combination in concrete.

$$\text{Compressive strengrth (MPa)} = \frac{\text{Failure load}}{\text{cross sectional area}}$$

Concrete Preparation

Mixing of cement sand and aggregate for M_{25} mix proportion that is in the ratio 1:1:2 with addition of water in ratio of 0.4 by weight of cement.

Bagasse ash used of passed sieve 125 µ.

The type of curing selected is Immersion tank curing.

Average of the result is taken for 7 days, 14 days as well as 28 days.

VI. RESULTS AND DISCUSSION

Bagasse ash powder were seived through IS 125 µ seive.

6.1. Bagasse ash

- Moisture content :-0.94%
- Ash content:-91.65%
- Volatile matter :- 2.51%
- Carbon Content :- 4.89 %

6.2. Setting Time Test

Concistency was found out to be 31 % for Ordinary Portland Cement. Keeping concistency constant through the test for intial and final setting time quantity of water taken is 0.85 % of concistency of OPC.

Table 5.2: Initial and Final Setting Time.

Sr. No.	Replacement of cement by using bagasse ash	Initial setting time (min)	Final Setting time (min)
1	0% (SCBA)	144	256
2	10% (SCBA)	125	243
3	20% (SCBA)	107	215
4	30% (SCBA)	85	190

6.3. Workability Test

For Slump cone and Compaction factor tests, water cement ratio is taken to be **0.4**

Table 5.3: Workability of Concrete

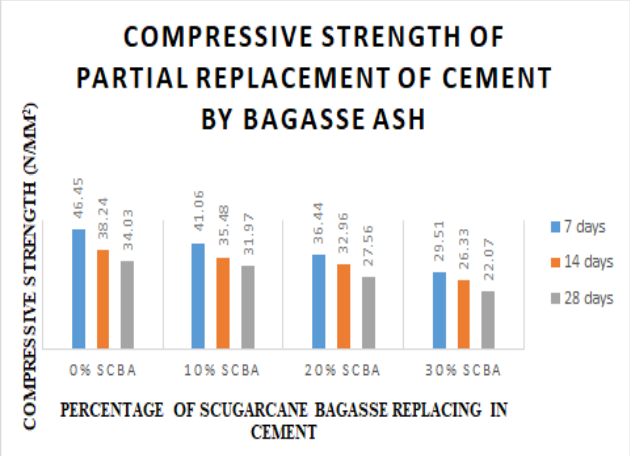
Sr. No.	Replacement of cement by using bagasse ash	Slump Cone (mm)	Compaction Factor
1	0% (SCBA)	85	0.87
2	10% (SCBA)	64	0.85
3	20% (SCBA)	43	0.82
4	30% (SCBA)	2	0.79

5.1 Compressive Strength Test

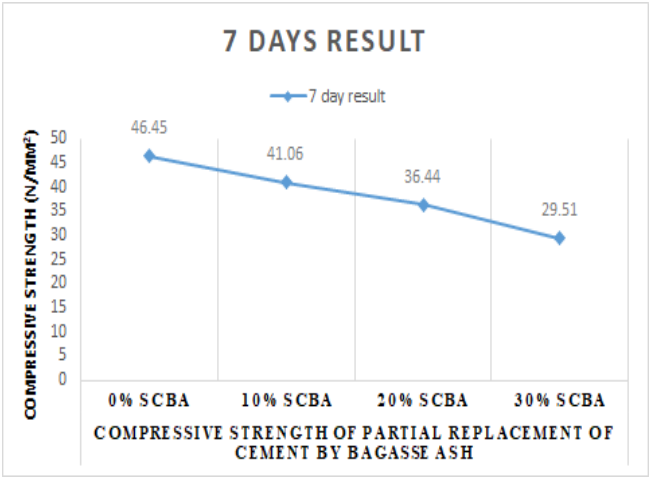
Table 5.4 Comprrssive Strength of Concrete.

Days	Compressive strength of Partial replacement of Cement by Bagasse ash			
	0% SCBA	10% SCBA	20% SCBA	30% SCBA
7	46.45	41.06	36.44	29.51
14	38.24	35.48	32.96	26.33
28	34.03	31.97	27.56	22.07

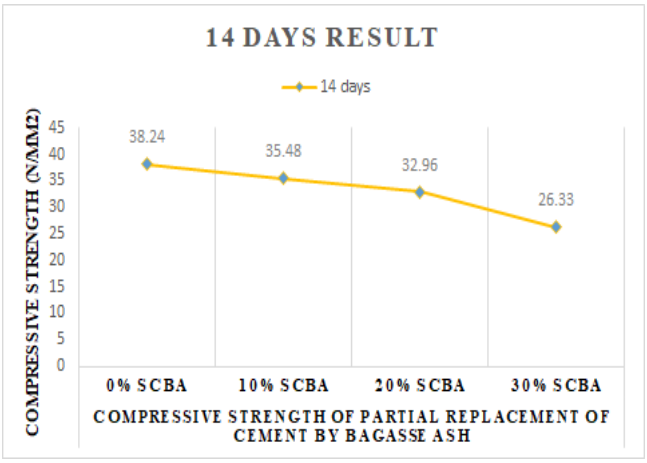
Graph 5.4.1: Compressive strength of partial replacement of cement by bagasse ash.



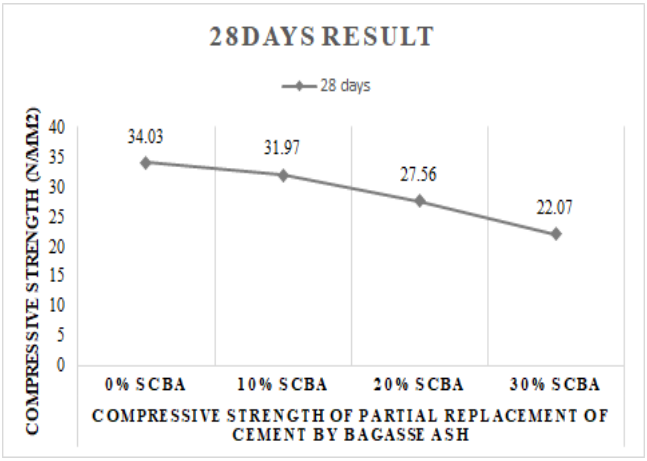
Graph 5.4.2: 7 Days Result



Graph 5.4.3: 14 Days Result



Graph 5.4.4: 28 days result



VII. CONCLUSION

1 Here in this segment there is decrease in initial and final setting time after increasing in % of bagasse ash.

2 There is only slight decrease in compressive strength after increase in % of replicable materials, but only up to 20% replacement. Hence 20% of replacement is beneficial to add according to result obtained.

3 Bagasse Ash absorbs more water as compare to cement hence water cement ratio is need to be increased.

4 It accelerate the setting time of cement.

5 Bagasse ash can be effectively utilize in concrete hence problem of disposal will easily solved. It is more economical than cement.

6 Reducing of quantity of cement in concrete, emissions of CO_2 gas can be minimize.

7 The outcomes of Slump cone test and compaction factor test shows less value in the results which conclude that workability is less for 0.4 water cement ratio.

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