Utilization of SCBA as Supplementary Cementacious Material in Concrete

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Abstract

The utilization of waste materials in concrete manufacture provides a satisfactory solution to some of the environmental concerns and problems associated with waste management. Agro wastes such as rice husk ash, wheat straw ash, hazel nutshell and sugarcane bagasse ash are used as pozzolanic materials for the development of blended cements. Few studies have been reported on the use of Bagasse Ash (BA) as partial cement replacement material in respect of cement mortars. In this study, the effects of BA content as partial replacement of cement on compatibility of cement with bagasse ash and mechanical properties of hardened concrete are reported. The properties of concrete investigated include compressive strength, flexural strength, and heat of hydration. The test results indicate that BA is an effective mineral admixture, with 10% as optimal replacement ratio of cement.
Keywords: Bagasse ash, compressive strength and heat of hydration

I. INTRODUCTION

Researchers all over the world today are focusing on ways of utilizing either industrial or Agricultural waste, as a source of raw materials for industry. This waste utilization would not only be economical, but may also result in foreign exchange earnings and environmental pollution control. Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials. Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in electric generation industry. When this bagasse is burned under controlled conditions; it gives ash having amorphous silica, which has pozzolanic properties. Therefore it is possible to use sugarcane bagasse ash (SCBA) as cement replacement material to improve quality and reduce the cost of construction materials in concrete. This bagasse ash has been chemically and physically Characterized replaced in different proportion with cement and incorporated in concrete. A few studies have been carried out in the past on the utilization of bagasse ash obtained directly from the industries to study pozzolanic activity and their suitability as binders by partially replacing cement.

Dominica and other countries Besides SCBA, rice husk ash, palm Kernel husk ash, fly ash, ground blast-furnace slag and silica fume have pozollonic properties that can be used in partial replacement of cement. Megat (2011) investigated the effect of silica fume, metakoalin, fly ash and granulated blast fume on workability, compressive strength, elastic modulus and porosity of high strength concrete. Concrete produced from partial replacement of cement with SCBA has reaction formed by silicate, SiO_2 from SCBA and slaked lime, $Ca(OH)_2$ from cement to form calcium silicate hydrate which is responsible for the compressive strength (Baguant, 1995). The quality of concrete produced from SCBA beyond an optimum quantity of SCBA will leaches out silicate which does not contribute to the strength of concrete (Baguant, 1995). The present study was carried to study the use of SCBA as a partial replacement of cement. The experimental study examines with 5%, 10%, 15% replacement of cement with bagasse ash by volume.

II. METHODS AND MATERIAL

The present investigation on behavior of cement with partial replacement of Suger Cane Bagasse Ash(SCBA) in different combinations, involves preparing four mixes; control concrete (100% C), SCBA1 (95% C + 5% BA), SCBA2 (90% C + 10% BA) and SCBA3 (85% C + 15% BA). Specimens for each mix were cast with each batch comprising of 2 cubes to obtain compressive strength and 12 beams.

Ordinary Portland cement of 43 grade satisfying the requirements of IS: 8112-1989 was used in the study. Natural sand as fine aggregate and natural gravel was used as the coarse aggregate for concrete production. Aggregates were obtained from local source with maximum size of coarse aggregate confined to 12.5 mm. The bagasse ash used in the investigation is obtained from a Corporate Sugar Factory nearby "BHANGOOR" vicinity. The Chemical Composition of Bagasse Ash having the components are SiO_2, Al_2O_3, Fe_2O_3, CaO, K_2O, MgO, SO_3, Loss of Ignition. The reference concrete mix proportion used was 1:2.07:3.31 (cement: fine aggregate: coarse aggregate) with water/binder ratio of 0.55.

III. RESULTS AND DISCUSSION

A. *Cement Tests*

Table – 1
Cement tests with replacement of bagasse ash

SI.NO / *Particulars*	*Normal Consistency (%)*	*Initial setting time(min)*	*Final setting time*
Control Concrete	*34*	*36*	*370*
SCBA1	*41*	*45*	*306*
SCBA2	*43*	*56*	*390*
SCBA3	*47*	*65*	*426*

When cement is replaced with bagasse ash, normal consistency, initial setting time and Final setting time increases with increase in % of bagasse ash.

By the above test results, it concludes that normal consistency, initial setting time and final setting time increased with increase in % of bagasse ash because as particle size of bagasse ash are finer has higher density, hence higher will the specific gravity. As it is finer than cement and acquires more water normal consistency, initial setting time and final setting time increased.

B. *Workability Tests*

Table - 2
Workability tests with replacement of cement by bagasse ash

SI.NO / *Particulars*	*Slump (mm)*	*Compaction factor*
Control Concrete	*30*	*0.88*
SCBA1	*29*	*0.88*
SCBA2	*30*	*0.90*
SCBA3	*45*	*0.92*

From above test results, as the slump value of normal concrete is 30mm, when the bagasse ash is added by replacement of cement with 5%, 10% and 15% the slump value gradually increases with increase in bagasse ash in concrete mix. Higher the percentage of bagasse ash higher will be the slump value. The compaction factor value increases as the slump value increases. When the bagasse ash is added in percentages in concrete mix as slump value increased compaction factor value also increases. As w/c ratio increases with the addition of bagasse ash the concrete can compact more uniformly.

C. *Tests on Hardened Concrete*

1) Compression Test

Compressive test is the most common of all tests on hardened concrete. It is used to estimate the potential strength of concrete. The compressive strength tests were carried out in accordance with IS: 1727-1999, IS: 516- 1959. The test cube was placed centrally between the platens of a compression testing machine, with trowelled face sideways. The load was then applied such that the stress increased at a constant rate (2kN/sec.) until failure. The maximum load was recorded. Compressive strength fc is determined as the maximum load (failure load) of the specimen that can withstand over the contact load area. It is expressedas

$$f_c = \frac{\text{Failure load}}{\text{Area}} \text{ MPa}$$

Fig. 1: The compression testing arrangement for concrete cubes.

Table – 3
The compressive strength of concrete with replacement of cement by bagasse ash

Sl. No.	*Control specimen (Mpa)*	*SCBA1 (Mpa)*	*SCBA 2 (Mpa)*	*SCBA 3 (Mpa)*
1	*26.56*	*26.66*	*34.66*	*26.61*
2	*27.34*	*17.77*	*31.11*	*24.01*
Average	*53.9*	*22.22*	*32.88*	*25.31*

The compressive strength of normal concrete is 28Mpa, as when bagasse ash is replaced with cement in percentages, the compressive strength increases with increase in percentage of bagasse ash up to the optimum value that is 10%. Further increase in bagasse ash in concrete mix, it reduces the compressive strength of concrete.

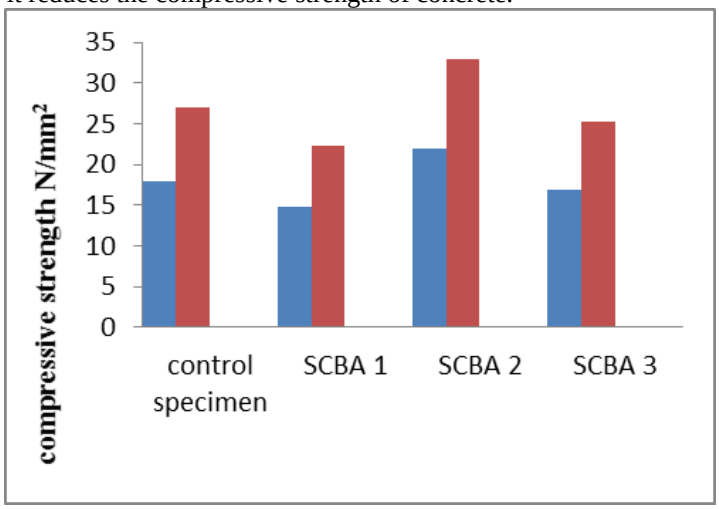

Fig. 2: compressive strength v/s % of replacement of cement with bagasse ash

2) Flexural Strength

In the point flexural loading test, a 100x100x500 mm concrete beam is loaded at a rate of 400 Kg/min. The flexural strength of the specimen shall be expressed as the modulus of rupture R shall be calculated as follows

$$R = \frac{PL}{bd^2}$$

Where R is the modulus of fracture, P the maximum indicated load, L the span length, b the width and d the depth of the specimen. The formula is valid only if fracture in the tension surface is within the middle third of span length. If the fracture is outside by not more than 5% of the span length, a modified formula is used

$$R = \frac{3Pa}{bd^2}$$

Where 'a' is equal to the average distance between the line of fracture and the nearest support support measured on tension surface of the beam.

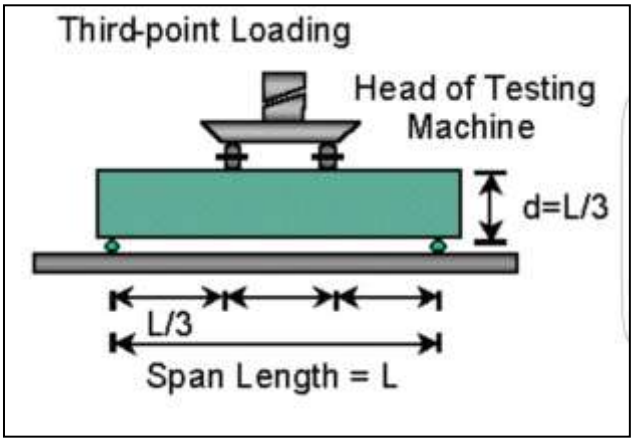

Fig. 3: Flexural testing of beam modal specimen

Table - 4
The Flexural strength of concrete with replacement cement by bagasse ash

particulars	*Control specimen*	*SCBA1*	*SCBA2*	*SCBA3*
Flexural strength 7Days (Mpa)	*0.97*	*1.12*	*1.14*	*0.98*
Flexural strength 28Days (Mpa)	*3.13*	*3.63*	*3.69*	*3.19*

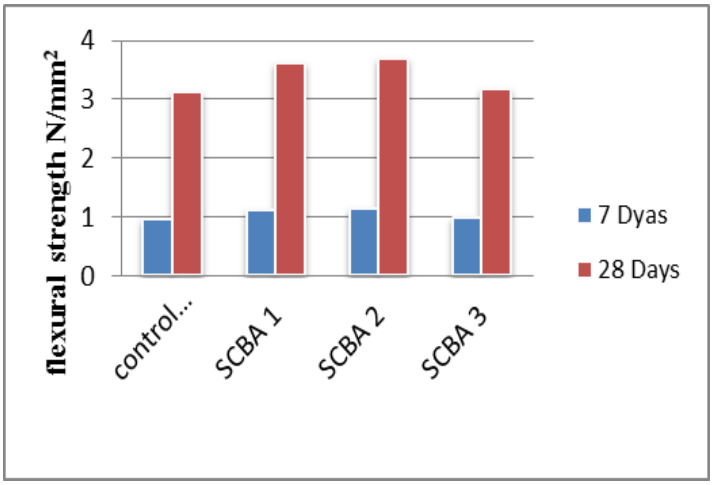

Fig. 4: flexural strength v/s % of replacement of cement with bagasse ash

The flexural strength of normal concrete is 3.13MPa, as the cement is replaced with bagasse, the flexural strength increases with increase in percentage of bagasse ash up to 10%. After 10% there is a gradual decrease in flexural strength value.

3) Hydration of Cement

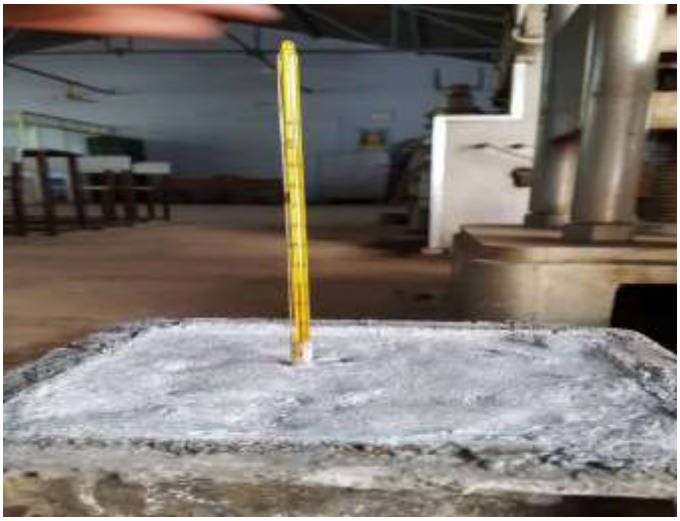

Fig. 5: Heat of hydration test by thermometer

The temperature in heat of hydration for normal concrete increases with regular interval of time, when the bagasse ash is replaced with cement in concrete mix the temperature decreases with regular interval of time. For every 5% increase in bagasse ash in concrete mix the temperature decreases.

Table - 5
Heat of hydration of concrete with replacement of cement by bagasse ash

Sl.no	*Time*	*Heat of hydration(SCBA2)*	*Control specimen*
1	*0min*	*37*	*32*
2	*30min*	*37*	*32*
3	*60min*	*36*	*31*
4	*90min*	*35.5*	*30.5*
5	*120min*	*35.5*	*30.5*
6	*150min*	*35*	*30*
7	*180min*	*34.5*	*45*
8	*210min*	*34*	*29*
9	*1day*	*29*	*24*

IV. CONCLUSION

1) The cement test such as normal consistency, initial setting time, final setting time, fineness increases with increase in percentage of bagasse ash from 5% to 15%.
2) The workability test values such as slump, compaction increases with increase in percentage of bagasse ash from 5% to 15%.
3) The compressive strength increases with increase in percentage of bagasse ash upto 10%, after which it decreases at 15%.
4) The flexural strength increases with increase in percentage of bagasse ash upto 10%, after which it decreases at 15%.
5) The heat of hydration for optimal percentage (10%) of bagasse ash with cement decreases with increase in time.

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