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Experimental Investigations of SCBA-Blended Concrete

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Abstract— Need for sustainable development has demanded the utilization of wastes from various industries in all possible applications. Sugarcane bagasse ash is one of such wastes available in huge quantity and has found to have pozzolanic characteristics. The amorphous silica in sugarcane bagasse ash comes into play when it is produced in controlled conditions, hence study was carried out to justify the pozzolanic behaviour of bagasse ash obtained from local sugar industry near Pandharpur. Present paper deals with study on effect of partial replacement of cement by sugarcane bagasse ash on the compressive strength of M20 grade of concrete. The cement was partial replaced by SCBA in the percentage of 0, 5, 10, 15, 20, 25 and 30% by weight of cement and it was observed that 20% replacement of cement by SCBA has no negative effect on compressive strength of concrete. Hence 20% replacement of cement by SCBA will result in economical production of concrete.
Keywords- Bagasse Ash, Compressive Strength, Pozzolanas, Sustainable Development.

I. INTRODUCTION

Bagasse is an agro waste product of sugar industries; left after the extraction of juice from the cane. It is mainly composed of cellulous fibres, cube sugar and water along with lignin. Due to its fibrous nature it finds its application in paper industries where approximately 0.3 tons of paper can be produces from each tone of bagasse. It is also used in production of wood, animal food, compose and bricks. Sugarcane contains 25-30% of bagasse which is a huge amount of waste. Even after its uses in above mentioned cases a large quantity of this waste is left as remainder which is normally utilized as energy source (for boiler feeding) in sugar production. Initially bagasse has yellow colour which turns into black after uncontrolled burning due to high amount of carbon content. The environmental issues and the need for sustainable development has demanded the effective utilization of such wastes as economical substitute so as to reduce the cost and conserve energy in all possible applications. The experimental investigations by Abbasi and Zargar [1], Singh et al. [2] have justified the pozzolanic behaviour of the finely ground sugar cane bagasse ash (SCBA).

The hydration of cement paste produces CSH gel and $Ca(OH)_2$; CSH gel is cementatious binder whereas Ca(OH)2 is a leachable product which when in contact with water disintegrates and leads to progressive failure of concrete. The pozzolanas although inert are rich in amorphous silica which react with free lime and convert it into cementetious material. The pozzolanic behaviour of the SCBA is reflected when the bagasse is burned under controlled conditions. Amin [3] suggest the burning at 700^0 C for one hour whereas Goyal et al. [4] specify burning SCBA at 600^0 C for five hours to obtain the non-crystalline sugar cane bagasse ash.

Being accepted as pozzolanic material, SCBA has been used in concrete and mortar production by a number of research workers. Studies by Hailu and Dinlu [5] on M35 grade of concrete suggests 10% replacement of cement by bagasse ash for better concrete properties. Rukzon and Chindaprasirt [6] studied the effect of replacement of cement by bagasse ash on the various properties of concrete such as compressive strength, porosity, coefficient of water absorption, chloride penetration and chloride diffusion to conclude that 30% replacement is acceptable for producing high strength concrete. Amin [7] studied the effect of replacement on chloride resistivity along with compressive strength to conclude that 20% replacement can reduce chloride diffusion by more than 50% without adversely affecting other properties of concrete. Abdulkadir et al [8] experimentally conclude that 10% and 20% replacement has 83.2 and 64.5% pozzolanic activity index as per ASTM-595, hence recommended for reinforced concrete. Similar studies were carried out by Kawade et al. [9], Shruthi et al. [10], Srinivas and Sathiya [11] and Piyanut et al. [12] to justify the utilization of SCBA in concrete production.

Present study deals with assessment of properties of M20 grade of concrete blended with sugarcane bagasse ash. The SCBA passing through 90 micron (60%) and 40 micron (40%) is used to replace cement in concrete production and the effect of replacement on the compressive strength of concrete is investigated.

II. Materials and Experimental Details

2.1. Materials

53 grade Portland cement confirming to IS: 12269-1957 was utilized in concrete production throughout the study. Locally available river sand confirming to zone II of IS: 383-1970 and having specific gravity of 2.605 and fineness modulus of 7.6 was used as fine aggregate. The crushed aggregates in the proportions of 60-40% retained respectively on 20 mm and 12.5 mm is sieves with combined specific gravity of 2.882 confirming to IS: 383-1970 were used as coarse aggregates. The design stipulations along with relevant IS specifications are tabulated in Table 1.

Table 1: Design Stipulations.

Material	Property		Relevant IS Code
Cement	Specific Gravity	3.15	IS: 2720 (Part 3)
	Fineness	4	IS: 4031-1996 (Part 1)
	Consistency	31	IS: 4031-1996 (Part 4)
	Initial Setting Time	44	IS: 4031-1996 (Part 5)
	Final Setting Time	246	IS: 4031-1996 (Part 5)
Fine Aggregates	Specific Gravity	2.605	IS: 2386(Part III)-1963
	Bulk Density	1.406	
	Water Absorption	0.2	
Coarse Aggregates	Specific Gravity 20 mm Aggregates	2.884	IS: 2386(Part III)-1963
	Specific Gravity of 10 mm Aggregates	2.878	
	Combined Specific Gravity	2.882	
Water	pH	7.2	IS: 456-2000

Sugarcane bagasse ash was collected from Pandurang Sahakari Sakhar Karkhana, a sugar industry located in the vicinity of Pandharpur; in the state of Maharashtra. Initially SCBA was black in colour due to high carbon content and uncontrolled burning which was further burned at around 500 to 650^0 C for nearly 5 hours to obtain non crystalline SCBA so that resulting amorphous nature with dominating silica content will react with $Ca(OH)_2$ or free lime to convert it into cementetious material. The typical chemical composition of SCBA is tabulated in Table 2.

Table 2: Typical Oxide Contents of SCBA.

Oxides	Range (in %)
SiO2	60-70
Al2O3	1-2
Fe2O3	5-10
CaO	2-4
MgO	0.5-2
K2O	0.5-1
SO3	0-0.5
LiO	10-20
SiO2+ Al2O3+ Fe2O3	65-80

2.2. Mix Proportioning

To assess the pozzolanic characteristics of SCBA, Portland cement was partially replaced by SCBA in the varying percentage of 0, 5, 10, 15, 20, 25 and 30% by the weight of cement. The proportion for reference mix of M30 grade of concrete was determined with the aid of IS: 10262-2009 and it was designated as P_0. The proportions with replacement of cement by SCBA were designated as P_5, P_{10}, P_{15}, P_{20}, P_{25} and P_{30} which are summarized in table 3.

Table 3: Mix Proportions.

Designation	% SCBA	% Cement	Cement	SCBA	Sand	Aggregates	Water
P_0	0	100	290	0	662	1534	156
P_5	5	95	275.5	14.5	662	1534	156
P_{10}	10	90	261	29	662	1534	156
P_{15}	15	85	246.5	43.5	662	1534	156
P_{20}	20	80	232	58	662	1534	156
P_{25}	25	75	217.5	72.5	662	1534	156
P_{30}	30	70	203	87	662	1534	156

3. Results and Discussion

The concrete cubes of 150 mm size were cast with above mentioned mix proportions as tabulated in Table 3 and were tested for compressive strength as per stipulations laid by IS: 516-1959. The seven and twenty eight days compressive strengths were determined and are tabulated in table 4.

Table 4: Compressive Strength of SCBA-Blended Concrete.

Designation	7 Days Compressive Strength	28 Days Compressive Strength
P_0	16.641	24.116
P_5	15.973	24.885
P_{10}	18.286	26.797
P_{15}	15.620	23.022
P_{20}	14.198	20.323
P_{25}	12.864	18.154
P_{30}	11.346	16.820

Figure 1 shows the variations in the seven days compressive strength. It can observed that the maximum seven days compressive strength is achieved in the percentage replacement of 10-15% by weight of cement, which is even higher than the reference mix proportion. Also it is observed that 5% (P_5 Proportion) replacement results in 4% less strength compared to reference mix but 10% replacement (P_{10} Proportion) results in 9.88 % increased seven days strength.

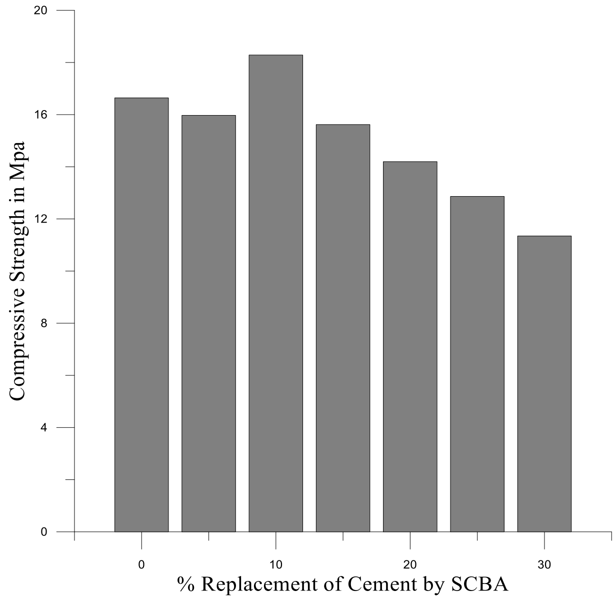

Figure 1: Variations in Seven Days Compressive Strength for Different % of SCBA.

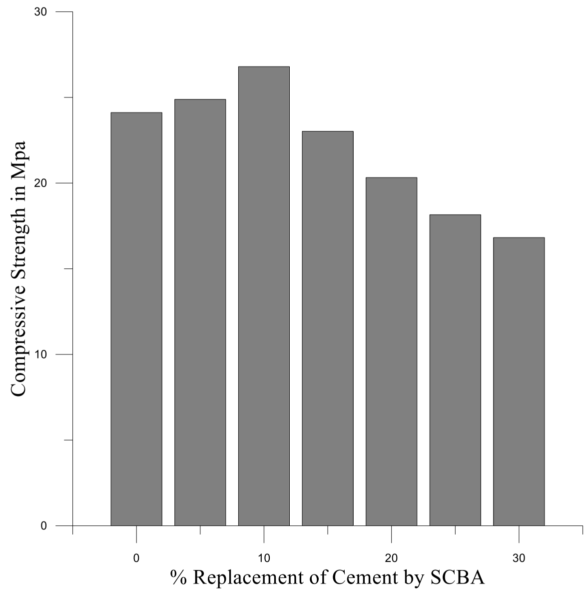

Figure 2: Variations in Twenty-eight Days Compressive Strength for Different % of SCBA

Similarly Figure 2 shows the variations in twenty eight days compressive strength for different percentage replacements of cement by SCBA. From the plot it can be observed that there is gradual increase in compressive strength as cement is replaced by SCBA up to 10% replacement after which there is decrease in compressive strength but still the value remains in acceptable limits (within 5%). The strength for 20% replacement is even though less as compared to reference mix but is greater than the desired strength that is 20 Mpa. Hence it can be concluded that 20% replacement of cement by SCBA proves to be economical without significantly affecting the compressive strength of concrete

III. CONCLUSION

The present study was carried out to investigate the effect of replacement of cement by SCBA on the compressive strength of concrete. From the experimental investigations following conclusions were be drawn out.

1. The literature survey shows that SCBA reflects pozzolanic characteristics if produced under controlled conditions. During present study SCBA was produced by burning bagasse ash at the temperature in the range of $500\text{-}650^0$ C.
2. There is decrease in seven days compressive strength value for 5% replacement of cement by SCBA but for 10% replacement maximum seven days strength is achieved with 9.88% increased strength as compared to reference mix.
3. The twenty eight days strength is also maximum at 10% replacement but 20% replacement also gives compressive strength of 20.323 Mpa which is also greater than desired value of 20 Mpa.
4. Hence 20% replacement of cement by SCBA produced under controlled conditions is recommended for economical concrete production. Authors also suggest that durability aspects should be assessed before implementing present work in important constructions.

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