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Experimental study on compressive strength of concrete by partially replacement of cement with sugar cane bagasse ash

Jayminkumar A. Patel*, Dr. D. B. Raijiwala**
*(M. Tech Student, Applied Mechanics Department, S. V. National Institute of Technology, Surat, Gujarat, INDIA-395007)
** (Associate Professor, Applied Mechanics Department, S. V. National Institute of Technology, Surat, Gujarat, INDIA-395007)

ABSTRACT
Use of waste material in concrete is important for environmental aspect. Sugar cane bagasse ash is a waste by product of sugar mill. Present study is to investigate impact of sugar cane bagasse ash in concrete. In this experimental work sugar cane bagasse ash which is taken from Maroli sugar mill, Navsari, Gujarat, INDIA is partially replace with cement at 0%, 5%, 10%, 15% and 20% by weight in concrete. The grade of concrete is M25 and w/c ratio is 0.49 taken as a reference. 150*150*150 mm cubes are casted and tested for 7, 14, 28 and 56 days. Compressive strength result shows that up to 10% replacement of sugar cane bagasse ash in concrete gives comparable result with normal concrete without any admixture, but 5% replacement give maximum compressive strength. Also the amount of sugar cane bagasse ash increase, workability of concrete increases.
Keywords **-** Compressive strength, Concrete, Partial replacement, Sugar cane bagasse ash, Workability

I. INTRODUCTION

Cement is the most important element of the infrastructure and can be a durable construction material. However, the environmental aspect of cement has become a growing concern, as cement manufacturing is responsible for about 2.5% of total worldwide waste emissions from industrial sources [1]. One effective way to reduce the environmental impact is to use mineral admixtures, as a partial cement replacement both in concrete and mortar, which will have the potential to reduce costs, conserve energy, and minimize waste emission [2][3]. Mineral admixtures are found in various forms in nature, including blast furnace slag, fly ash, and silica fume. The use of mineral admixtures improves the compressive strength, pore structure, and permeability of the mortars and concretes because the total porosity decreases with increasing the hydration time [4].India is the second in the major sugar producing countries after Brazil [5]. Bagasse is a major by-product of the sugar industry, which is utilized in the same industry as an energy source for sugar production [6]. Residual from sugar industry and bagasse bio mass burned under controlled conditions gives ash having amorphous silica, which has pozzolanic properties [7]. After the burning process, bagasse ash is produced, and this value tends to increase annually because sugar- cane is the major raw material used in the production of sugar and ethanol. Utilization of bagasse ash is minimal compared to its production, and good methods for its disposal are unavailable. Some applications of bagasse ash include materials for backfill, fertilizer, and removal of heavy metals from waste water [8–10]. Thus, most of the bagasse ash is still disposed of as waste in landfills, causing environmental and other problems. An economical viable solution to this problem should include utilization of waste materials for new products which in turn minimize the heavy burden on the nation's landfills. Recycling of waste construction materials saves natural resources, saves energy, reduces solid waste, reduces air and water pollutants and reduces greenhouse gases. The construction industry can start being aware of and take advantage of the benefits of using waste and recycled materials.

Fig.-1 Sugar cane bagasse

II. EXPERIMENTAL PROGRAM

II.1 Materials used in this research are:

II.1.1 **Cement:** The most commonly used cement in concrete is Ordinary Portland Cement of 53 Grade conforming IS 12269 [11].

II.1.2 **Fine Aggregate:** Locally available free of debris and nearly riverbed sand is used as fine aggregate. The sand particles should also pack to give minimum void ratio, higher voids content leads to requirement of more mixing water. In the present study the sand confirms to zone I as per Indian standards [12]. The specific gravity of sand is 2.69. Those fractions from 4.75 mm to 150 micron are termed as fine aggregate.

II.1.3 **Coarse Aggregate:** The crushed aggregates used were 20mm and 10mm nominal maximum size and are tested as per Indian standards and results are within the permissible limit [12].

II.1.4 **Water:** Water available in the college campus conforming to the requirements of water for concreting and curing as per IS: 456-2009 [13].

II.1.5 **Sugarcane Bagasse Ash:** The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicellulose and 25% 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 experimental study sugarcane bagasse ash was collected from the Maroli Sugar Factory, Kalasana (Kalyan Nagar), National Highway 228, Taluka .Jalalpore, District-Navsari, Gujarat, India - 396415.

Fig. 3 Sugar cane bagasse ash


Fig. 4 Maroli sugar factory, Navsari, Gujarat, INDIA

II.2 Chemical analysis of sugar cane bagasse ash

Sugar cane bagasse ash collected for experimental work was tested for the chemical compound at Pollucon laboratories PVT LTD, Surat. Chemical compound result of bagasse ash is follow:

Table 1: Chemical composition of SCBA

Chemical compound	Abbreviation	%
Silica	SiO2	68.42
Aluminium Oxide	Al2O3	5.812
Ferric Oxide	Fe2O3	0.218
Calcium Oxide	CaO	2.56
Phosphorous Oxide	P2O5	1.28
Magnesium Oxide	MgO	0.572
Sulphide Oxide	SO3	4.33
Loss on Ignition	LOI	15.90

Table 2: Chemical composition of SCBA

Chemical compound	Abbreviation	Mg/kg
Sodium Oxide	Na2O	1621
Potassium Oxide	K2O	9406
Manganese Oxide	MnO	244
Titanium Oxide	TiO2	240
Barium Oxide	BaO	23.73

III. CASTING OF SPECIMEN

Preparation of the Specimens: Sugar cane bagasse ash used in experiment work was oven dry at 120^0 C to complete removal of moisture and ash passing through 300 micron sieve before use.

Fig.-5 Sugar Cane Bagasse Ash after oven dry

Concrete cubes of size 150x150x150 mm were casted. The 53 grade OPC was replaced with 0%, 5%, 10%, 15% and 20% sugar cane bagasse ash by weight.

Concrete mix proportion material parameters:

1) Grade of concrete – M25
2) Type of cement – OPC 53Grade
3) Type of aggregate:
4) Fine aggregate < 4.75mm
5) Coarse aggregate (greet) – 10mm
6) Coarse aggregate – 20mm
7) Water cement ratio – 0.49

8) Time period of curing – 7days, 14days, 28days and 56days

Fig.-6 Casted specimen put for dry

IV. TESTING OF SPECIMEN

Specimen were tested for compressive strength after curing period of 7th day, 14th day, 28th day and 56th day of curing in Compressive Testing machine [15].

Fig-7 Sample in compression testing machine

Fig.-8 Specimen after testing

V. RESULTS

The strength results obtained from the experimental investigations are showed below.

Workability

A high-quality concrete is one which has acceptable workability (around 6.5 cm slump height) in the fresh condition and develops sufficient strength. Basically, the bigger the measured height of slump, the better the workability will be, indicating that the concrete flows easily but at the same time is free from segregation. Maximum strength of concrete is related to the workability and can only be obtained if the concrete has adequate degree of workability because of self compacting ability. The results show that unlike the 0% SCBA concrete, all investigated SCBA mixtures had high slump values and acceptable workability. This may be due to the increasing in the surface area of sugarcane ash after adding sugar cane bagasse ash that needs less water to wetting the cement particles.

Table 3: Workability of fresh concrete

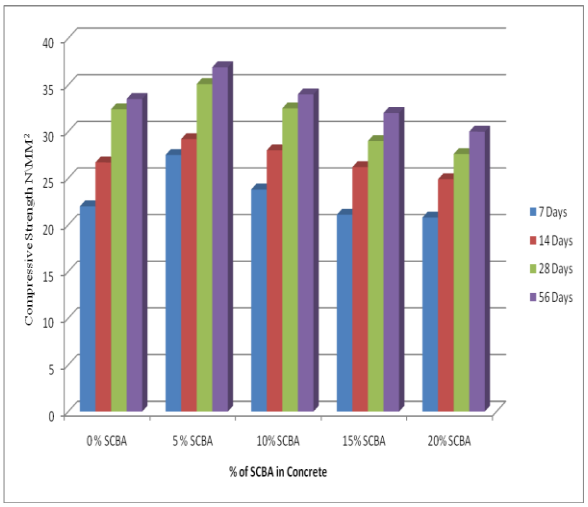
% SCBA in Concrete	Slump (mm)
0	74
5	165
10	187
15	210
20	234

Compressive strength

All the values are the average of the three samples in each case in the testing program of this study.

Table 4: Compressive strength result

SCBA	7Days N/mm^2	14Days N/mm^2	28Days N/mm^2	56Days N/mm^2
0 %	22	26.7	32.4	33.5
5 %	27.5	29.2	35.1	36.9
10%	23.8	28	32.5	34
15%	21.1	26.2	29	32
20%	20.8	24.9	27.6	30



Graph-1 Comparision of compressive strength result of specimen at 7th, 14th, 28th and 56th day

VI. CONCLUSION

The result shows that the sugar cane bagasse ash in concrete have significantly higher compressive strength compare to the normal concrete. It was found that cement can be replaced with sugar cane bagasse ash with maximum limit of 10%. But result shows that maximum strength of concrete was achieved with 5% replacement of cement with sugar cane bagasse ash without any super plasticizer. After that there was decreasing the strength of concrete with increasing of sugar cane bagasse ash in concrete.

VII. FUTURE WORK

From this experiment it clear that 5% replacement of cement with SCBA gives maximum compressive strength. But it also requires finding out optimum amount of SCBA that can be use in concrete. Also it requires checking various properties of concrete like Modulus of elasticity, Split tensile test, Flexure test with variation of SCBA in concrete.

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