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Abstract- India is the second largest in major sugar producing countries after Brazil. Due to that there is increase in bagasse as a by product from the sugar mill. Bagasse is the fibrous residue of sugar cane after crushing and extraction of juice. Sugar cane bagasse ash is the waste product of the combustion of bagasse for energy in sugar factories. Sugar cane bagasse ash is disposed of in landfills and is now becoming an environmental burden. In this experimental research work concrete cubes, beams and cylinders of M25 grade were casted and tested to examine various properties of concrete like workability, compressive strength, split tensile strength, modulus of elasticity and flexural strength. Sugar cane bagasse ash was partially replaced with cement at 2, 4, 6 and 8 % by weight of cement in concrete. From the results we can conclude that optimum amount of sugar cane bagasse ash that can be replaced with cement is 6% by weight without any admixture.

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I. Introduction

A modern lifestyle, alongside the advancement of technology has led to an increase in the amount and type of waste being generated, leading to a waste disposal crisis. Several issues exist regarding reducing waste. A key environmental issue is waste incinerators, furnaces for burning trash, garbage and ashes. These incinerators produce 210 different dioxin compounds plus mercury, cadmium, nitrous oxide, hydrogen chloride, sulphuric acid and fluorides. Produced also in incinerators is particulate matter that is small enough to remain permanently in the lungs. Additionally, waste incinerators generate more CO_2 emissions than coal, oil, or natural gas-fuelled power plants. For years, scientists and researchers have been searching for possible solutions to environmental concerns of waste production and pollution. Many have found that replacing raw materials with recycled materials reduces our dependency on raw materials in the construction industry. The problem of waste accumulation exists worldwide, specifically in the densely populated areas. Most of these materials are left as stockpiles, landfill material or illegally dumped in selected areas. Large quantities of this waste cannot be eliminated. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the "Waste Hierarchy''. Its aim is to reduce, re use, or recycle waste, the latter being the preferred option of waste disposal. Fig. 1 shows a sketch of the waste hierarchy.

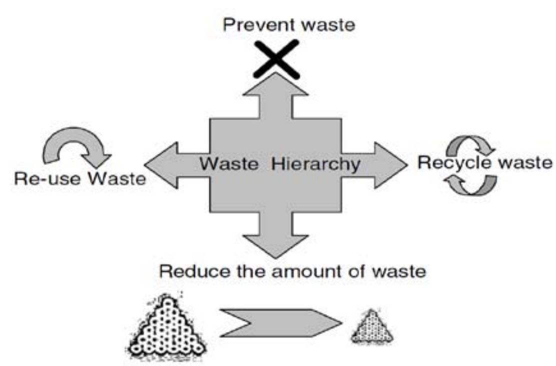

Figure 1 : Sketch of Waste Hierarchy

A waste management plan directs the construction activities towards an environmentally friendly process by reducing the amount of waste materials and their discard in landfills. The environmental and economic advantages that occur when waste materials are diverted from landfills include:

a) Conservation of raw materials;
b) Reduction in the cost of waste disposal; and
c) Efficient use of the materials.

Sugar cane is one of the major crops grown in over 110 countries and its total production is over 1500 million tons. In India sugar cane production is over 300 million tons/year that cause around 10 million tons of sugar cane bagasse ash as an un-utilized and waste material. In India, a large amount of sugar cane bagasse from sugar mills is available. For each 10 tonnes of sugar cane crushed, a sugar factory produces nearly 3 tonnes of wet bagasse. Since bagasse is a by-product of the sugar industry, the quantity of production in each

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year is in line with the quantity of sugar cane produced. Sugar cane bagasse is partly used at the sugar mill as fuel for power generation. However, the bagasse ash has been considered being a waste, which causes the problems of disposal. For instance, the landfills of bagasse ash are still the problem of power plants because the waste of ash is currently not useful for any works. Furthermore, if the sugar cane bagasse is burned under the controlled temperature and atmosphere, the bagasse ash will be a highly reaction. The bagasse ash with high silica content could also be used as pozzolans. Bagasse ash is recently accepted as a pozzolanic material which is obtained as a by-product of the sugar industry. However, the study of using bagasse ash as a pozzolans is not well-known especially the effects of LOI of bagasse ash on the compressive strength and sulphate resistance. A survey from many sources in Thailand found that LOI of bagasse ash is very high (larger than 10%) and well over the limit for pozzolans in concrete. Bagasse ash contains amorphous silica and displays good pozzolanic properties, but its uses are limited and most of it is disposed in landfills. Moreover, sugar factories use different process of burning and collecting which affects the physical and chemical properties of the ash. To overcome environment effect and utilisation of sugar cane bagasse ash study has been done to replace the cement with sugar cane bagasse ash in concrete and result reported in this paper.

After the extraction of all juice sugar from sugarcane, 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 sugar cane bagasse ash (SCBA). In this study we try to use sugar cane bagasse ash in concrete and reduce environmental problem and waste disposal problem.

Figure 2 : Sugar cane bagasse and Sugar cane bagasseash

II. Materials Used in Experimental Work

The materials used in this study are:

Cement: The most commonly used cement in concrete is ordinary portland cement of 53 Grade conforming BIS 12600-1989(2009).

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. (BIS: 10262, BIS: 383). The specific gravity of sand is 2.62. The bulk density of fine aggregate is 1715 kg/m^3.

Coarse Aggregates: 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. (BIS: 10262, BIS: 383). The specific gravity and bulk density of 10mm and 20 mm aggregate are 2.74 and 2.79 and 1472 kg/m^3 and 1438 kg/m^3 respectively.

Water: Water available in the college campus conforming to the requirements of water for concreting and curing as per BIS: 456-2000.

Figure 3 : Checking Sugar cane bagasse ash taken from sugar mill and removing unburned particles

Chemical analysis of SCBA: 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	SiO_2	68.42
Aluminium Oxide	Al_2O_3	5.812
Ferric Oxide	Fe_2O_3	0.218
Calcium Oxide	CaO	2.56
Phosphorous Oxide	P_2O_5	1.28
Magnesium Oxide	MgO	0.572
Sulphide Oxide	SO_3	4.33
Loss on Ignition	LOI	15.90

Table 2 : Chemical composition of SCBA

Chemical compound	Abbreviation	mg/kg
Sodium Oxide	Na_2O	1621
Potassium Oxide	K_2O	9406
Manganese Oxide	MnO	244
Titanium Oxide	TiO_2	240
Barium Oxide	BaO	23.73

III. Experimental Work

For the experiment work M25 grade of concrete was used. Water cement ratio was taken as 0.49 throughout work. Sugar cane bagasse ash was oven dried before use to remove moisture. Total 60 no's of cube of size 150*150*150 mm, 8 no's of beam size 500*100*100 mm, 8 no's of cylinders size 150mm diameter and 300mm height specimen were casted. Cast iron moulds of standard sizes were used for casting cubes, cylinders and beams. The specimens were demoulded after 24 hours from the commencement of casting and submerged under water till the time of testing.

Figure 4 : Specimen after casting putting for dry for 24 hours

a) Compression Testing

Compression testing of cubes was done on compression testing machine having capacity of 3000kN. Compressive strength of sugar cane bagasse ash contain concrete cubes was determined after 7, 14, 28 and 56 days moist curing as per BIS 9013-1978.

Figure 5 : Compression testing of concrete cubes specimen before and after testing

b) Flexure Testing

Flexural strength test is done as per BIS: 516-1959. Beams are tested for flexure in Universal testing machine as shown in figure. The axis of the specimen is aligned with the axis of the loading device. The specimen is loaded till it fails and the maximum load applied to the specimen during test is noted.

Figure 6 : Testing of beam for flexural strength and sample after testing

c) Modulus of Elasticity

Testing of modulus of elasticity was done on automatic compression testing machine having capacity of 3000KN. Cylinders were placed with ring having digital dial gauge attached which transmitting signal to the computer. Centre of the ring was coinciding with the centre of cylinder.

Figure 7 : Testing of modulus of elasticity of concrete cylinder and sample after testing

d) Split Tensile Test

Testing for split tensile strength of concrete is done as per BIS 5816-1999. The test is conducted on automatic compression testing machine of capacity 3000kN as shown in fig. The cylinder is placed horizontally between the loading surfaces of compression testing machine and the load is applied till failure of the cylinder. During the test the plates of the testing machine should not be allowed to rotate in a plane perpendicular to the axis of cylinder.

Figure 8 : Split tensile testing of concrete cylinder and sample after testing

IV. Results and Discission

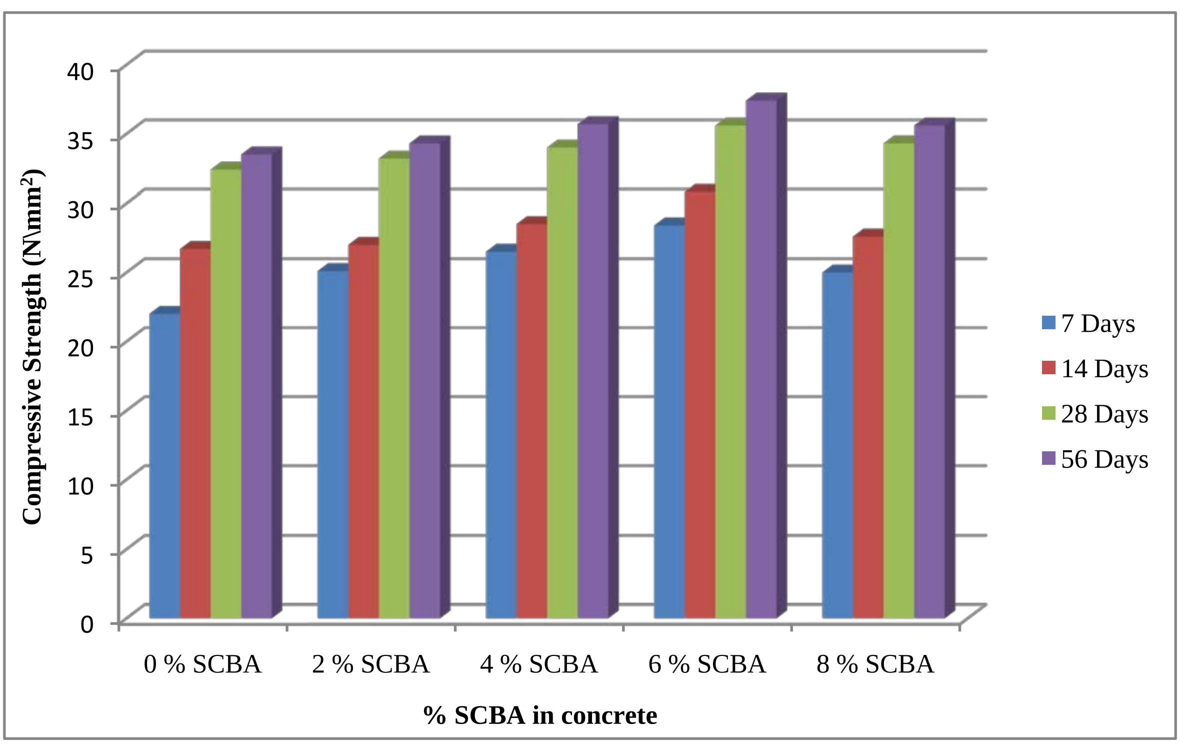
Workability

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
2	122
4	148
6	171
8	180

➢ Compressive strength of sugar cane bagasse ash contain concrete cubes was determined after 7, 14, 28 and 56 days moist curing

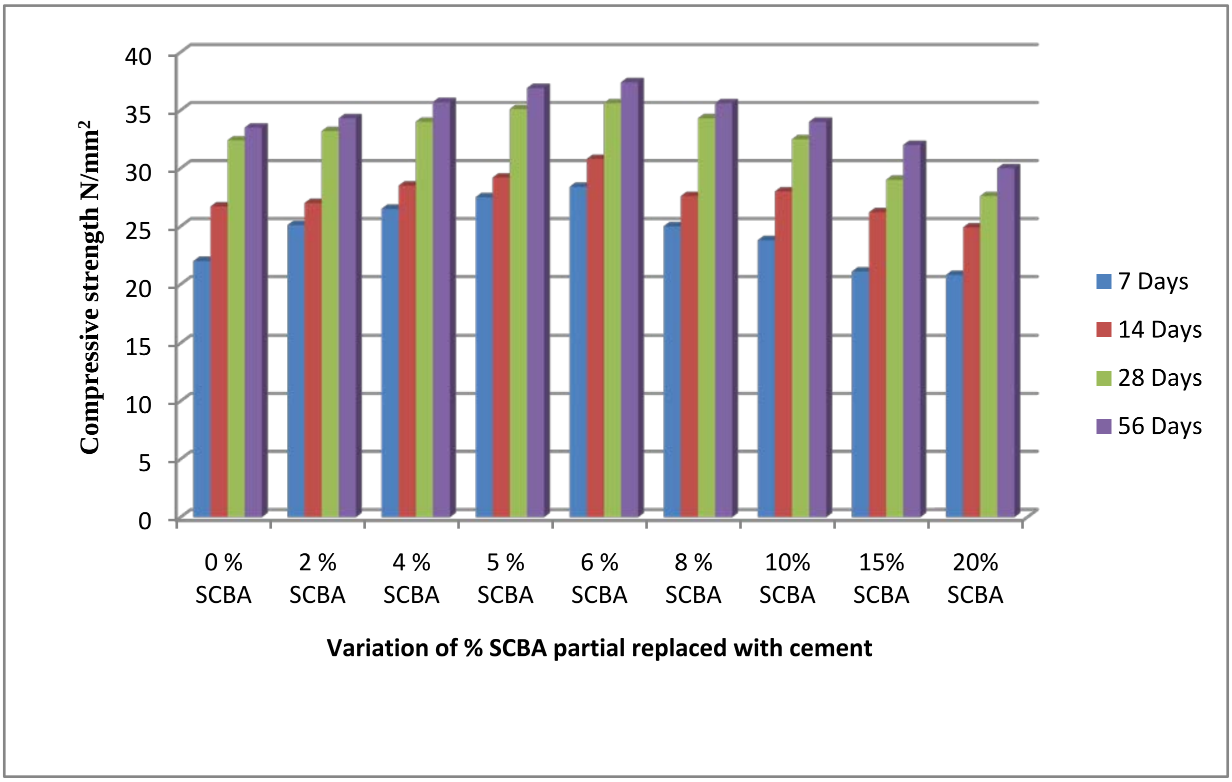


Graph 1- Comparision of compressive strength result of specimen at 7th, 14th, 28th and 56th day

Table 4 : Concrete specimen testing results after 28 days with variation of SCBA in concrete

Sample Designation	% of SCBA in concrete	Compressive Strength MPa	Split Tensile Strength MPa	Flexural Strength MPa	Modulus of Elasticity MPa	Bulk Density Kg/m^3
J1	0	32.46	2.96	5.94	22840	2582.60
J2	2	33.20	3.51	6.15	21390	2516.74
J3	4	34.00	3.56	7.05	20600	2471.85
J4	6	35.60	3.64	8.85	18710	2438.21
J5	8	34.30	3.53	6.60	17480	2417.32

- With the combination of current experimental results with previous results [8]. We can get the below graph of compression strength of concrete with the variation of sugar cane bagasse ash contain replaced with cement in concrete.



Graph 2- Compression strength of concrete cubes with variation of % of SCBA

V. Conclusion

Results we obtained from the experimental work shows that sugar cane bagasse ash can be replaced with cement in concrete. Pulverized bagasse ash is a suitable pozzolanic material for use in concrete. From the experimental results we can conclude that replacement of sugar cane bagasse ash with cement can be up to 10% by the weight of cement without significant loss in strength of concrete. But the optimum amount of sugar cane bagasse ash that can be replaced with cement is 6% to get maximum strength of concrete. With 6% replacement of sugar cane bagasse ash, compressive strength increase 9.67% compare to normal concrete after 28 days of curing. After 6% replacement of sugar cane bagasse ash there is decrease in strength of concrete with increase of replacement of sugar cane bagasse ash. Also split tensile strength and flexural strength increase with 6% replacement of sugar cane bagasse ash compare to normal concrete. Also sugar cane bagasse ash can be use as admixture in concrete due to high % of silica present in it. The above results show a beneficial application of the use of sugar cane bagasse ash and reduce the environment problem and also minimize the requirement of land fill area to dispose sugar cane bagasse ash.

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