A STUDY ON BAGASSE ASH REPLACED PLAIN CEMENT CONCRETE

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ABSTRACT

This experimental and analytical study investigates the strength performance of concrete using Ordinary Portland Cement and Sugarcane Bagasse Ash. Sugarcane Bagasse Ash was obtained by burning of Sugarcane at 700 to 800 degree Centigrade and the Bagasse Ash were then ground until the particles passing the 150 micron. The disposal of this material is already causing environmental problems around the sugar factories. A huge shortage is created in most of the construction materials especially cement, resulting in steady increase of price. This experimental study conducted to examine the potential of Bagasse ash as a cement replacing material which is similar to that of Ordinary Portland Cement. Five different concrete mixes with the Bagasse Ash replacement of 0%, 5%, 10%, 15% and 20% to the Ordinary Portland cement were prepared for M_{25} grade concrete with water to cement ratio of 0.5 and 383.16kg/m^3 cement content respectively. The properties of these mixes have then been assessed both at the fresh and hardened state. The results of the present study depicts that up to 10% replacement of the Ordinary Portland Cement by Bagasse ash achieved a higher compressive strength, split tensile strength and flexural strength at all test ages of 7, 28, 56 and 90 days.

Keywords— Compressive Strength, Flexural Strength, Split Tensile Strength, Sugarcane Bagasse Ash

I. INTRODUCTION

Cement which is one of the ingredients of concrete plays a great role, but it is most expensive. Therefore requirements for economical and more environmental-friendly cementing materials have extended interest in other cementing material that can be used as a partial replacement of the normal Portland cement. Ground Granulated Blast Furnace Slag (GGBS), Fly Ash (FA), Silica Fume (SF) have been used successfully for this purpose. 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 [1]. for this reason sugarcane bagasse ash (SCBA) is one of the main by-product can be used as mineral admixture due to its high content in silica (SiO2). The ash, therefore, becomes an industrial waste and poses disposal problems [2].

Sugarcane bagasse is an industrial waste which is used worldwide as fuel in the same sugar-cane industry [3]. Recently Sugarcane Bagasse Ash (SBA), which is a byproduct of sugar factories found after burning sugarcane bagasse which in turn is found after the extraction of all economical sugar from sugarcane has been tested in some part of the world for its pozzolanic property and has been found to improve some of the properties of the paste, mortar and concrete like compressive strength and water tightness in certain replacement percentages and fineness [4].

The main composition of bagasse ash is siliceous oxide sio_2 that react with free lime from cement hydration [5]. The pozzolanic property of SBA came from the silicate content of the ash. This silicate under goes a pozzolanic reaction with the hydration products of the cement and results a reduction of the free lime in the concrete. The silicate content in the ash may vary from ash to ash depending on the burning and other properties of the raw materials like the soil on which the sugar cane is grown [6]. Therefore, this study attempts to make use of the SBA in India as a pozzolanic material to replace cement. An experimental investigation was carried out explore its Consistency, setting time, workability, compressive strength, split tensile strength, flexural strength and durability characteristic.

II. MATERIALS AND METHODOLOGY

Cement: In this present study 43 grade Ordinary Portland Cement (OPC) is used for all concrete mixes. The cement used is fresh and without any lumps. The testing of cement is done as per IS: IS 8112 - 1989 [7]. The specific gravity, normal consistency, initial and final setting time of cement was found as per Indian standard specifications.

Fine aggregate: The sand used in this present study is ordinary river sand. The sand passing through 4.75 mm size sieve is used in the preparation of concrete mix. The sand confirms to grading Zone II as per IS: 383-1970 [8]. The properties of sand such as fineness modulus and specific gravity were determined as per IS: 2386-1963 [9]. The specific gravity of fine aggregate is found to be 2.65. The water absorption is 0.5%. The bulk density of fine aggregate in loose and compact state is 1579 kg/m^3 and 1689 kg/m^3 respectively.

Coarse aggregate: The coarse aggregate used in this present study is 20 mm down size locally available crushed stone obtained from local quarries. The physical properties have been determined as per IS: 2386-1963 [9]. The specific gravity of coarse aggregate is found to be 2.68. The water absorption is 0.25%. The bulk density of coarse aggregate in loose and compact state is 1471 kg/m^3 and 1565 kg/m^3 respectively.

Water: The water used in the mixing of concrete was potable water and its free from suspended solids and organic materials.

Sugarcane Bagasse Ash: The SBA used in this present study was taken from Sugar factory which is located in Pandavapura, Mandya district of Karnataka State, India. It was not possible to measure the temperature in the furnace while taking the bagasse ash, because the measuring instrument was not long enough to go through the furnace. Even though it was not possible to measure the temperature, most furnaces have a temperature above that is required for complete combustion which is around 800^{o}C. But it was suggested that at a temperature around 650^{o}C the crystallization of minerals occurs. This reduces the pozzolanic activity of the bagasse ash.
For this study, fresh SBA taken from the furnace was used. It was cooled in air by applying a small quantity of water.

TABLE:1 CHEMICAL COMPOSITION OF SBA

Chemical Composition	Residual Bagasse Ash (%)
SiO_2	65.37
Al_2O_3	0.22
Fe_2O_3	5.98
CaO	1.50
LOI	21.04

EXPERIMENTAL WORK

In this study, a total 180 numbers of concrete specimens were casted. In those 60 numbers of cubes, 60 numbers of cylinders and 60 numbers of beams respectively. The cubes, cylinders and beams size were 150mm x150mm, 150mm diameter & 300 mm height and 500mm x100mm x100mm respectively. The mix design of concrete was done according to IS: 10262-2009 [10] for M_{25} grade. Adopted water cement ratio is 0.5. 0%, 5%, 10%, 15%, 20% of SBA was replaced by the weight of cement. The ingredients of concrete were thoroughly mixed in concrete mixer machine. Before casting oil was smeared to the inner surface of the moulds. Concrete was poured in to the moulds and compacted thoroughly using vibrator. The top of the surface was finished by means of a trowel. After 24 hours the specimens were removed from the mould and then cured under water for period of 7, 28, 56 and 90 days. The specimens were taken out from the curing tank just prior to the test. The test for compressive strength, split tensile strength were conducted using a 2000kN compression testing machine, the flexural strength was conducted by using universal testing machine.

III. EXPERIMENTAL RESULTS

The variation of compressive strength, split tensile strength and flexural strength of M_{25} grade of concrete with percentage replacement of SBA to cement content from the experimental and analytical investigations are tabulated in tables 2 to table 4 and Figure 1 to Figure 6 respectively.

TABLE II

COMPRESSION STRENGTH RESULTS OF SBA CONCRETE

% of SBA	7 days (MPa)	28 days (MPa)	56 days (MPa)	90 days (MPa)
B00%	19.84	31.85	34.51	37.62
B05%	22.07	32.88	36.58	40.73
B10%	24.99	35.40	40.44	44.14
B15%	17.92	24.58	30.51	34.21
B20%	15.85	23.25	27.25	30.36

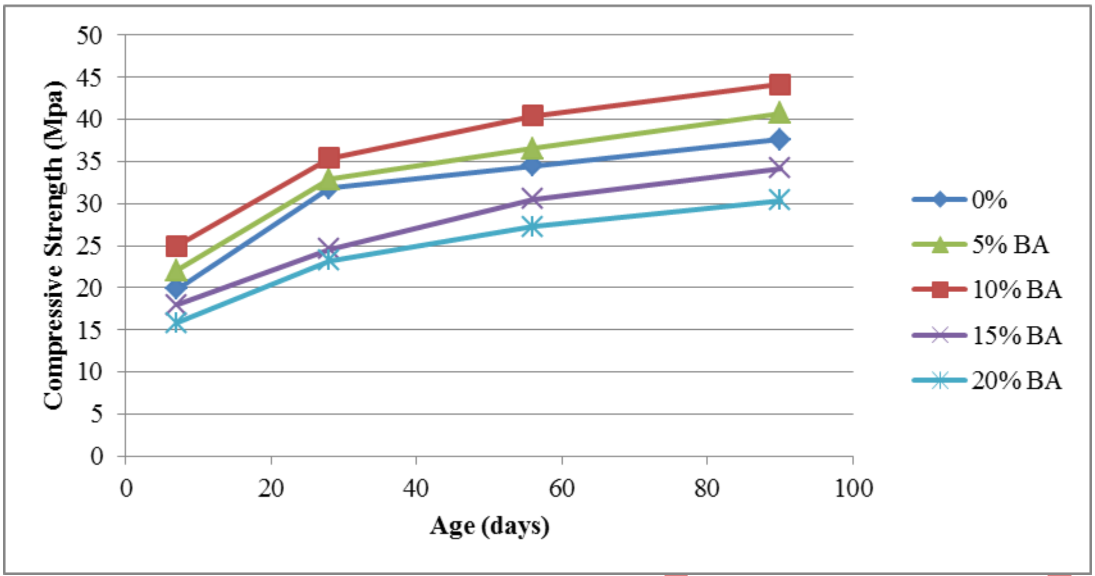

Figure 1: Compressive Strength of M_{25} Grade Concrete at Different Ages

TABLE III

SPLIT TENSILE STRENGTH RESULTS OF SCBA CONCRETE

% of SBA	7 days (MPa)	28 days (MPa)	56 days (MPa)	90 days (MPa)
B00%	1.50	2.44	2.92	3.48
B05%	2.07	3.06	3.48	4.05
B10%	2.49	3.48	4.05	4.61
B15%	1.13	1.69	2.16	2.63
B20%	0.80	1.36	1.79	2.16

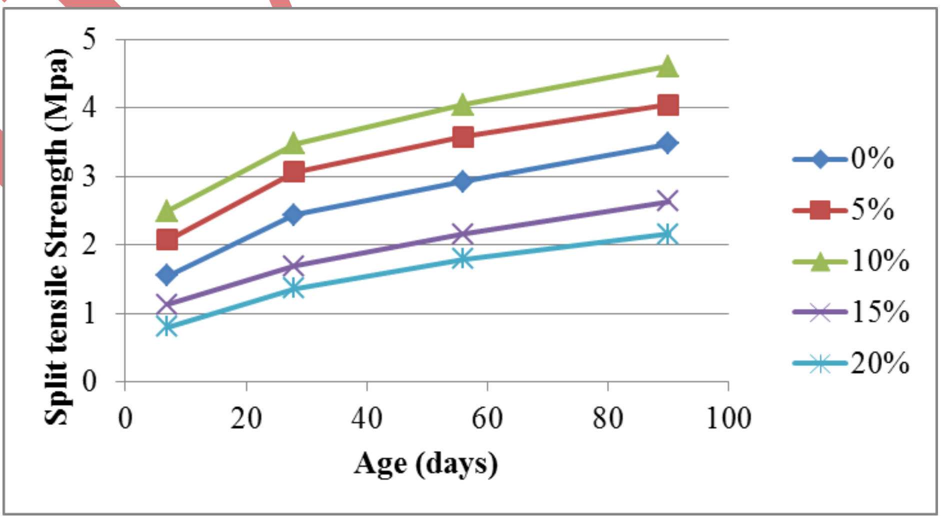

Figure 2: Split Tensile Strength of M_{25} Grade Concrete at Different Ages

TABLE IV

FLEXURAL STRENGTH RESULTS OF SCBA CONCRETE

% of SBA	7 days (MPa)	28 days (MPa)	56 days (MPa)	90 days (MPa)
B00%	7.08	9.52	10.41	10.94
B05%	8.25	10.35	10.86	11.16
B10%	9.43	10.71	11.48	11.92
B15%	6.55	8.98	9.42	10.16
B20%	5.94	7.87	8.85	9.36

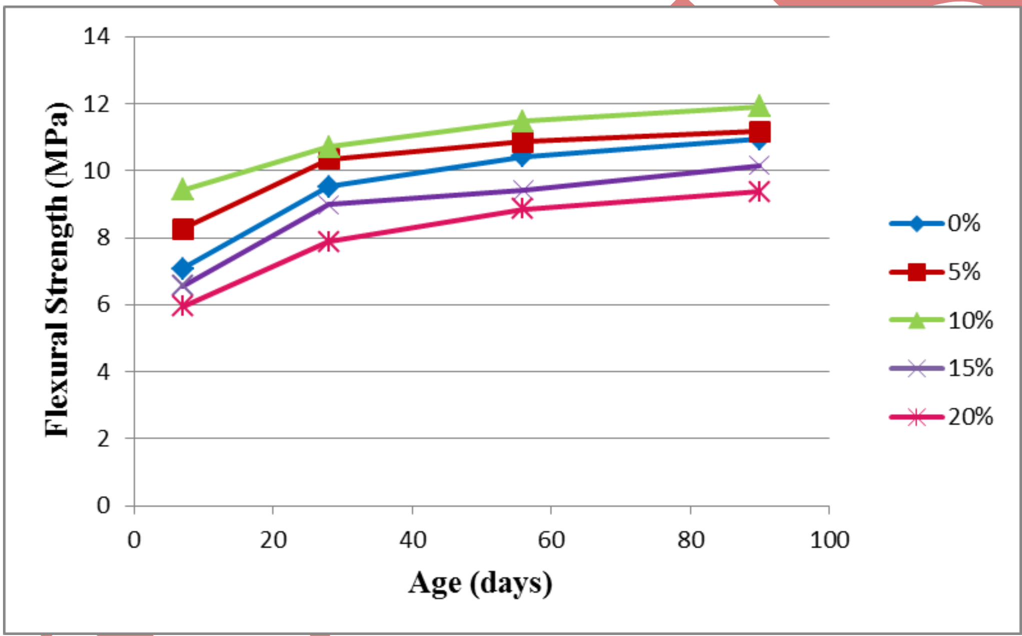

Figure 3: Flexural Strength of M_{25} Grade Concrete at Different Ages

ANALYTICAL RESULTS

The objective of curve fitting is to theoretically describe experimental data with a model (function or equation) and to find the parameters associated with this model.

Curve fitting is the process of constructing a curve, or mathematical function that as the best fit to a series of data points, possibly subject to constraints. Curve fitting can involve either interpolation, where an exact fit to the data is required, or smoothing, in which a "smooth" function is constructed that approximately fits the data. A related topic is regression analysis, which focuses more on questions of statistical inference such as how much uncertainty is present in a curve that is fit to data observed with random errors. Fitted curves can be used as an aid for data visualization, to infer values of a function where no data are available, and to summarize the relationships among two or more variables. Extrapolation refers to the use of a fitted curve beyond the range of the observed data, and is subject to a degree of uncertainty since it may reflect the method used to construct the curve as much as it reflects the observed data. Equation 1 to Equation 12 is the fourth order set of equations developed during the curve fitting by using the data set obtained during the experimental investigation. Number mentioned as suffix represents the age of concrete specimen and x represents the desired percentage of SBA (Here CS = Compressive Strength, ST= Split Tensile Strength and FS= Flexural Strength)

$CS_7=0.0017113x^4- 0.06558x^3 + 0.69802x^2 - 1.6185x + 19.84$ eq—(01)

$CS_{28}=0.0025107x^4 - 0.095093x^3 + 1.0168x^2 - 2.8147x + 31.85$ eq —(02)

$CS_{56}=0.0024027x^4- 0.092853x^3 + 1.0081x^2 - 2.6057x + 34.51$ eq—(03)

$CS_{90}=0.002228x^4 - 0.08515x^3 + 0.8933x^2 - 1.9943x + 37.62$ eq—(04)

$ST_7=0.0002964x^4 - 0.011053x^3 + 0.111x^2 - 0.20167x + 1.5$ eq—(05)

$ST_{28}=0.00037867x^4 - 0.01404x^3 + 0.14033x^2 - 0.274x + 2.44$ eq—(06)

$ST_{56}=0.00043x^4 - 0.016193x^3 + 0.16785x^2 - 0.37617x + 2.92$ eq—(07)

$ST_{90}=0.000439x^4 - 0.01653x^3 + 0.17103x^2 - 0.38267x + 3.48$ eq—(08)

$FS_7=0.00069x^4 - 0.02611x^3 + 0.27067x^2 - 0.55153x + 7.08$ eq—(09)

$FS_{28}=0.000289x^4 - 0.01083x^3 + 0.10244x^2 - 0.11165x + 9.52$ eq—(10)

$FS_{56}=0.000468x^4 - 0.01784x^3 + 0.1891x^2 - 0.468x + 10.41$ eq—(11)

$FS_{90}=0.000436x^4 - 0.01716x^3 + 0.1919x^2 - 0.541x + 10.94$ eq—(12)

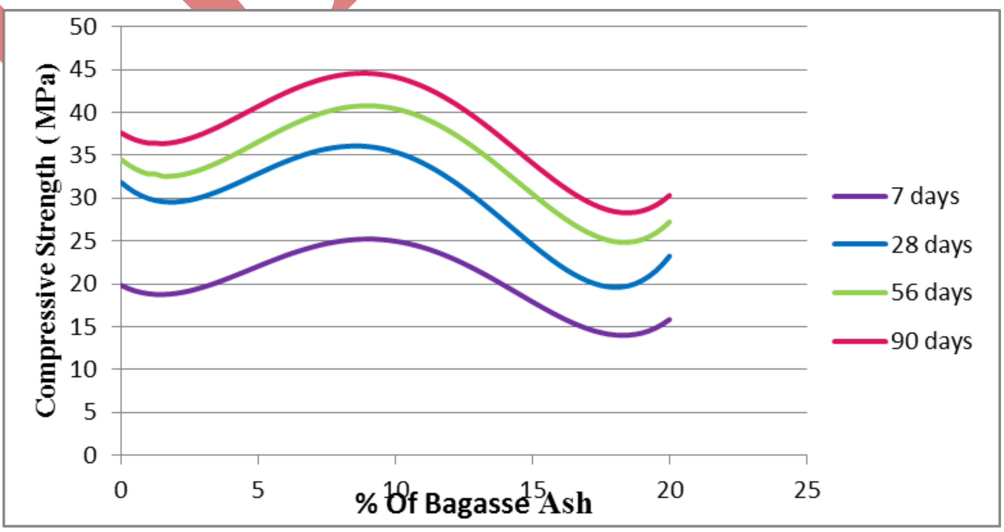

Figure 4: Compressive Strength of M_{25} Grade Concrete at

Different Percentage of Bagasse Ash content.

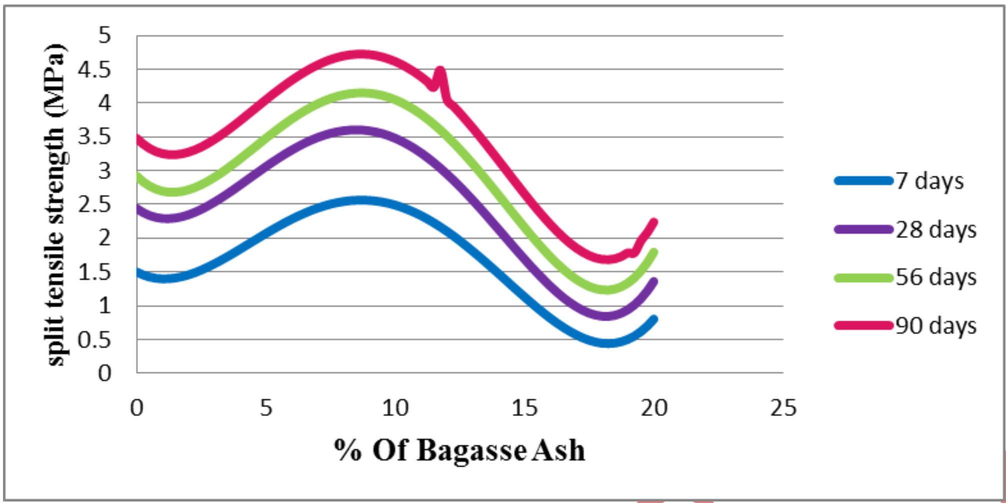

Figure 5: Split Tensile Strength of M_{25} Grade Concrete at different Percentage of Bagasse Ash content.

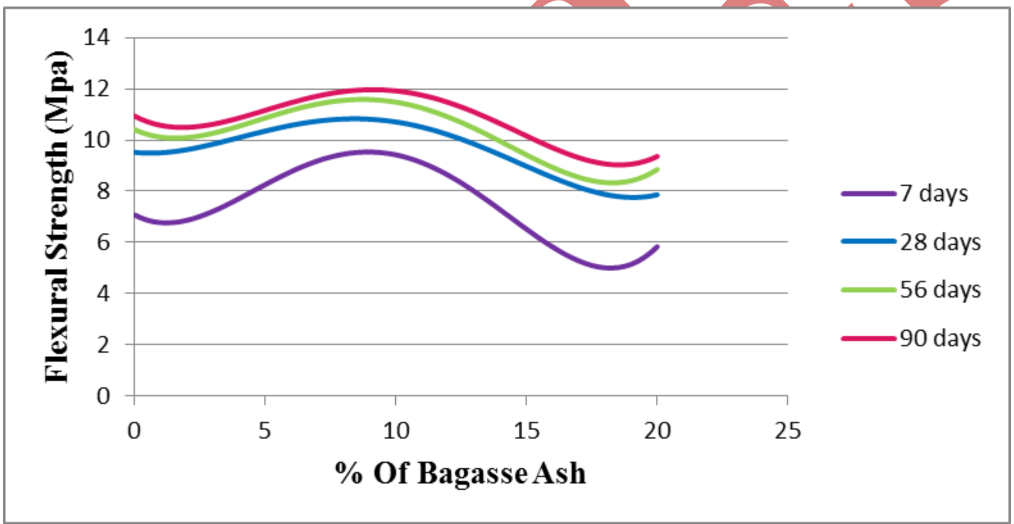

Figure 6: Flexural Strength of M_{25} Grade Concrete at different Percentage of Bagasse Ash content

IV. CONCLUSIONS

Detailed description of experimental results has been carried out. It has been observed that the experimental result for the 10% replacement of bagasse ash to OPC has increase in strength in comparison with 0% and 5% replacement. Beyond 10% replacement of bagasse ash, the strength was decreased. The analytical results obtained are not much varied compared to experimental results. It gives very near values to the experimental values so we can use the developed equations of this present study for the calculation of values compressive strength, split tensile strength and flexural strength for bagasse ash replacement with OPC up to 20% replacement.

AKNOWLEDGEMENT

The authors wish to thank the authorities of Visvesvaraya Technological University, Belgaum for giving an opportunity to conduct the experiments in the Concrete and Highway Engineering Laboratory of University BDT College of Engineering Davangere. 577004.

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