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EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT BY SUGARCANE BAGASSE ASH

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Abstract

The Bagasse ash imparts high early strength to concrete and also reduce the permeability of concrete. The Silica present in the Bagasse ash reacts with components of cement during hydration and imparts additional properties such as chloride resistance, corrosion resistance etc. Therefore, the use of Bagasse ash in concrete not only reduces the environmental pollution but also enhances the properties of concrete and also reduces the cost. It makes the concrete more durable. This project mainly deals with the replacement of cement with Bagasse ash in fixed proportions and analyzing the effect of HCl on SCBA blended concrete. The concrete mix designed by varying the proportions of Bagasse ash for 0%, 5%, 10%, 15%, 20% the cubes are been casted and cured in normal water and 5% HCl solution for ages of 7, 28 and 60 days. The test result indicates that the strength of concrete increase up to 10% Sugar cane bagasse ash replacement with cement. The natural, bio-degradable features and chemical constituents of the sugarcane bagasse (SCB) have been attracting attention as a highly potential and versatile ingredient in composite materials. Eco-friendly and low cost considerations have set the momentum for material science researchers to identify green materials that give low pollutant indexes.

Key Words - sugarcane bagasse ash, compressive strength, split strength, flexural strength, workability, concrete.

1. Introduction

In the manufacture of cement, the clinker production process requires a great amount of energy and emits a large amount of carbon dioxide (CO2) into the atmosphere. The increase in CO2 emissions has led to the greenhouse effect and an increase in the temperature of the Earth. To reduce the environmental problems, industrial and agricultural by-products such as fly ash, rice husk ash, silica fume metakaolin, granulated blast furnace slag, etc., have been used as supplementary cementing material to reduce the production of cement, thus reducing the emission of CO2 and the use of energy. Moreover, the incorporation of these cement replacement materials in concretes has been reported to improve the mechanical properties and penetration resistance of the concrete. Ordinary Portland cement is the most commonly used building material throughout the world and it will retain its status in near future also because of demand and expansion of construction industry all over the world. Further the greatest challenge before the concrete construction industry is to serve the two pressing needs of human society, namely the protection of environment and meeting the infrastructure requirements of our growing population Structures which are constructed in aggressive environments are liable to be subjected to acidic attack. One of such major problems is HCl attack against concrete structures due to which there will be loss of weight and reduction in strength of concrete ultimately sacrificing age of the structure. Contaminated ground water, seawater, industrial effluents are some of the sources of sulphate that attack concrete. The use of blended cements have shown a sharp results in resisting the sulphate attack on concrete, sugarcane bagasse ash which shows pozzolanic properties is being used as a partial replacement in concrete in regular intervals of 5% up to 15%. SCBA is being produced from sugar manufacturing units as a waste material which will be grinded to the fineness less than cement for obtaining good bonding between cement and SCBA. This project discusses the very severe exposure of HCl on concrete.

2. Literature Collection

Mr. R. Srinivasan et al.,(2010) has investigated on "Experimental Study on Bagasse Ash in Concrete". They had observed that Sugar Cane bagasse is fibrous waste-Product of sugar refining industry, and causing serious environmental problem which mainly contain aluminum ion and silica. Hear bagasse ash has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 15%, 25% by weight of cement in concrete. Fresh concrete tests like compaction factor test and slump cone test were undertaken, was well as hardened concrete test like compressive strength , split tensile strength, flexural strength and modulus of elasticity at the age of seven and 28 days was don. The results show that the SCBA in blended concrete had significantly higher compressive strength, tensile strength, and flexural strength compare to that of the concrete without SCBA. It is found that cement could be advantageously replaced with SCBA up to maximum limit of 10%..

Mr. U.R. Kawade et al.,(2013) had studied on "Effect of use of Bagasse ash on Strength of Concrete" they had Chemically and Physically Characterized and partial replaced in the ratio of 0%, 10%, 15%, 20%, 25% and 30% by weight of cement in concrete. The results show that the SCBA concrete had significantly higher compressive strength compared to that of the concrete without SCBA.

Mr. Lavanya M.R et al.,(2012) had studied on "A Experimental Study on the Compressive Strength of Concrete by Partial replacement of Cement with Sugar cane bagasse ash". The Feasibility of using sugar cane bagasse ash , a finely grounded waste product from the sugarcane industry, as partial replacement for cement in conventional concrete is examined. The test were conducted as per Bureau of Indian Standard (BIS) codes to evaluate the stability of SCBA for partial replacement up to 30% of cement with varying water cement (W/C) ratio. They showed that addition of SCBA results in improvement of strength in all cases and according o the results obtained, it can be concluded that Bagasse ash can increase the overall strength of concrete when used up to a 15% cement replacement level with W/C ratio of 0.35, bagasse ash is a valuable pozzolanic material and it can potentially be used as a partial replacement for cement.

Mr. H.S. Otuoze et al.,(2014) had investigated on "Characterization of Sugar Cane Bagasse ash and ordinary Portland Cement blends in Concrete" , The SCBA is obtained by burning Sugar cane Bagasse at between 600-700 degrees Celsius, since the sum of Sio2, Al2o3 and Fe2o3 is 74.44%, For strength test , mix ratio of 1:2:4 was used and OPC was partially replaced with 0% ,5%, 10%, 15%, 20%, 25%, 30%, 35%, 40% by weight in concrete. Compressive strength values of hardened concrete were obtained at the ages of 7,14,21,28 days. Based on the test conducted, it can be concluded that SCBA is a good pozzolana for concrete cementation and partial blends of it with OPC could give good strength development and other engineering properties in concrete. An optimum of 10% SCBA blends with OPC could be used for reinforced concrete with dense aggregate. Higher blends of 15% and up to 35% of SCBA with OPC are acceptable for plane or mass concrete. The value fell short of meeting requirements for reinforced. Concrete with dense aggregate because of excessive fines from increasing SCBA and reducing Strength of bonding.

Kanchana lata Sigh and S.M Ali Jawaid,(2016) had studied on "utilization of sugarcane Bagasse ash (SCBA) as Pozzolanic Material in concrete" Agricultural and industrial by-products are commonly used in concrete production as cement replacement materials CRMs or as admixtures to enhance both fresh and hardened properties of concrete as well save the environment from the negative effects caused by their disposal. Approximately 1500 Million tons of sugarcane is annually produced over all the world which leave about 40-45 % bagasse after juice crushing for sugar industry giving an average annual production of 675 Million tons of bagasse as a waste material. This paper examined the potential of bagasse ash for development as pozzolanic materials in concrete. The bagasse ash is a by-product from the combustion of bagasse as a fuel in thermal power plants and sugar cane industries. From review it may be concluded that Sugarcane Bagasse ash can be used as a pozzolanic material in concrete due to its high silica content. The results of this research indicated (10% sugarcane bagasse ash) in blended concrete had significantly higher compressive strength.

3. Experimental Investigation

3.1. Cement

Ordinary Portland cement of 53 grades conforming to IS: 12269-1987 was used for the present experimental investigation. The following experiments were conducted to identify the properties of cement as per IS code.

Table 1 Properties of cement

Properties of cement				
Standard consistency	**Specific gravity of cement**	**Fineness test**	**Initial setting time**	**Final setting time**
32%	3.16	7.11%	60 minutes	400 min

3.2. Fine Aggregate

Fine aggregate is sand, which is usually obtained from rivers or lakes. In places where sand is not available or a large quantity of sand is required, crushed stone dust is used. The fine aggregate should be free from clay particles because it reduces strength and it takes more amount of water during the period of concrete mixing. Tests Performed on Fine Aggregates as per IS 383-1970.

Table 2 Properties of fine aggregate

Properties of fine aggregate				
Sieve analysis of river sand	**Sieve analysis of M-sand**	**Specific gravity of river sand**	**Specific gravity of M-sand**	**Water absorption test**
2.58	2.84	2.63	2.73	0.5%

3.3. Coarse Aggregate

Coarse aggregate shall consist of naturally occurring materials such as gravel or resulting from the crushing of parent rock, including natural rock, slags, expanded clays and shelves (lightweight aggregates) and other approved inert materials with similar characteristics, having hard, strong, durable particles, conforming to the specific requirements of this Section.

The coarse aggregate gives volume, stability, resistance to wear or erosion, and other desired physical properties to the finished product. Tests performed on coarse aggregates as per IS 2386-1963

Table 3 Properties of coarse aggregate

Properties of coarse aggregate

Sieve analysis of coarse aggregate	Specific gravity of Coarse aggregate	Water absorption test	Impact test	Abrasion test
7.33	2.65	0.98	10.28	10.8

3.4. Sugarcane Bagasse Ash

Bagasse is a by-product from sugar industries which is burnt to generate power required for different activities in the factory. The burning of bagasse leaves bagasse ash as a waste, which has a pozzolanic property that would potentially be used as a cement replacement material. It has been known that the worldwide total production of sugarcane is over 1500 million tons.

Sugarcane consists about 30% bagasse whereas the sugar recovered is about 10%, and the bagasse leaves about 8% bagasse ash (this figure depend on the quality and type of the boiler, modern boiler release lower amount of bagasse ash) as a waste, this disposal of bagasse ash will be of serious concern.

Sugarcane bagasse ash has recently been tested in some parts of the world for its use as a cement replacement material. The bagasse ash was found to improve some properties of the paste, mortar and concrete including compressive strength and water tightness in certain replacement percentages and fineness. The higher silica content in the bagasse ash was suggested to be the main cause for these improvements.

Although the silicate content may vary from ash to ash depending on the burning conditions and other properties of the raw materials including the soil on which the sugarcane is grown, it has been reported that the silicate undergoes a pozzolanic reaction with the hydration products of the cement and results in a reduction of the free lime in the concrete.

Table 4 sugarcane bagasse ash

SI.NO	Particular	Result
1	Specific gravity	1.94
2	Fineness	90 micro
3	Colour	Black
4	Particle shape	Powder form

3.5. Water

Fresh potable water, which is free from acid and organic substance, was used for mixing the concrete. Fresh portable water free from organic matter and oil is used in mixing the concrete. Water in required quantities were measured by graduated jar and added to the concrete. The rest of the material for preparation of the concrete mix was taken by weigh batching. The pH value should not be less than 7.

4. Mix Proportioning

Concrete Mix Design In This Experiment Was Designed As Per The Guidelines In Is 10262-2009. All The Samples Were Prepared Using Design Mix. M30 Grade Of Concrete Was Used For The Present Investigation. Mix Design Was Done Based On Is 10262-2009. The Table 5 Shows Mix Proportion Of Concrete (Kg/M^3)

Table 5 Final Mix proportion: Conventional Mix

MIX PROPORTIONING	CEMENT (KG/M^3)	M-Sand (Kg/M^3)	FINE AGGREGATE (RIVER SAND) (Kg/M^3)	COARSE AGGREGATE (Kg/M^3)	WATER (litr)	SUGARCANE BAGASSE ASH (Kg/M^3)
CCM	425.73	647.11	-	1110.21	191.58	-
CCR	425.73	-	647.11	1110.21	191.58	-
CC.SBA5%	404.44	-	647.11	1110.21	191.58	21.28
CC.SBA10%	383.15	-	647.11	1110.21	191.58	42.57
CC.SBA15%	361.87	-	647.11	1110.21	191.58	63.85
CC.SBA20%	340.58	-	647.11	1110.21	191.58	85.14
C.C= Conventional Concrete, C.CM = Conventional concrete with M-sand, C.C.R= Conventional Concrete with River Sand, CC.SBA= Concrete With Sugarcane Bagasse Ash						

5. Fresh Concrete Properties

5.1. Slump cone Test

This test is performed to measure the workability of fresh concrete as per IS 1199-1959. Slump cone test is the most commonly used method of measuring consistency of concrete. It is used conveniently as a control test and gives an indication of the uniformity of concrete. Additional information on workability and quality of concrete can be obtained by observing the manner in which concrete slump. The apparatus for conducting the slump test essentially consist of a metallic mould in the form of frustum of the cone having the internal dimension of bottom diameter 20cm, top diameter 10cm, and a height of 30cm.

Fig 1 Slump cone Test

5.2. Compacting Factor test

Compaction factor test is the workability test for concrete conducted in laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. It was developed by Road Research Laboratory in United Kingdom and is used to determine the workability of concrete As per IS1199:1959 Compaction factor test apparatus consists of two conical hoppers and a bottom cylinder which is arranged as shown in Fig 3.7, steel rod of 1.6cm Diameter with a length of 61cm is used to tamp the concrete and a weight balance is used to weight the concrete.

Compaction factor = (W2-W1)/ (W3-W1)

Fig 2 Compacting Factor test

Table 6 Workability of fresh concrete

Workability	
Slump cone Test	**Compacting Factor test**
76	0.83

6. Hardened Concrete Properties

6.1. Compressive strength test

150 mm cube specimens were tested under compressive load in the respective to the age of curing. All the specimens were tested in saturated surface dry condition, after wiping out the surface moisture. For each mix combination, three identical specimens were tested at the ages of 7, 14, 28 days using compression testing machine of 2000 KN capacity under a uniform rate of loading of 140 kg/cm2/min. and the compressive strength will calculated as per IS: 516 – 1959. Fig. 3.8 shows the experimental set up of compressive testing machine.

Compressive Strength (f) = (P/A) N/mm2

Where,

P = Load at which specimen fails in Newton,

A = Area over which the load is applied in mm^2f =

Compressive Stress in N/mm^2

Fig 3 Experimental Set Up of Compressive Strength

6.2. Split tensile strength test

This is an indirect test to determine the tensile strength of cylindrical specimens. Split tensile strength tests were carried out on 100 mm dia.x200 mm high cylindrical specimen at the ages of 28 days of moist curing, using compression testing machine of 2000 N capacity as per IS 5816-1999.

Split tensile strength (ft) is estimated from the expression

$$T = 2P / \pi DL \ \ N/mm^2$$

Where,

T = Split tensile strength of concrete

P = Ultimate Load (Newton)

D = Diameter of cylinder (mm)

L= Length of cylinder (mm)

Fig 4 Experimental Set Up of Split Tensile Strength

6.3. Flexural strength test

In order to determine the flexural strength of concrete, prismatic specimens of a size 100 mm x 100 mm x 500 mm were cast with various proportions of all the concrete mixtures. After 28 days of moist curing the specimens were tested in flexural testing machine under a uniform rate of loading of 180 kg/cm^2/min. Flexural strength of specimens expressed as the modulus of rupture (fb) is then calculated using the formula and procedure given in IS: 516- 1959.

When the distance between the line of fracture and the nearer support, measured on centre line of the tension side of specimen (‘a’ in mm) is greater than133 mm for prism of size 100 mm x 100 mm x 500 mm, the modulus of rupture (fb) is then calculated from the Equations.

$$(fb) = Pl / bd^2$$

For ‘a’ is less than 133 mm but greater than 110 mm for prism specimen, then modulus of rupture is calculated from the formula.

$$(fb) = 3Pa / bd$$

Fig 5 Beam testing machine

7. Experimental Procedure

The specimen of standard cube of (150mmx150mmx150mm) and standard cylinders of (200mmx100mm) and beam of (100mmx100mmx500mm) were used to determine the compressive strength, split tensile strength and flexural strength of concrete. Three specimens were tested for 7,14&28 days before crushing.

The following experiments are conducted on the specimen is the compressive strength test, split tensile strength test and flexural strength test.

8. RESULTS AND DISCUSSION:

The normal concrete are tested for their performance by determining their compressive strength, splitting tensile strength and flexure strength development at different ages of 7th, 14th and 28th days. The results obtained are discussed in detail in the following sections.

8.1. Compressive Strength Result

Compressive strength test is done as Per IS 516-1959. The test is conducted on Compression testing machine of capacity 2000 KN. Mechanical behaviour of concrete was studied for M30 grade of cubes were casted and cured for 7,14 and 28days.The compressivestrength is computed from following formula.

Table 7 compressive strength result

Mix Designation	Mix proportion				Compressive strength N/mm^2		
	Cement	River sand	Sugarcane bagasse ash	Coarse aggregate	7 days	14 Days	28 Days
CC	100%	100%	0%	100%	20.06	28.77	31.04
SBA1	95%	100%	5%	100%	20.56	29.23	31.33
SBA2	90%	100%	10%	100%	21.54	30.42	33.68
SBA3	85%	100%	15%	100%	21.06	29.58	32.34
SBA4	80%	100%	20%	100%	20.12	28.67	31.28

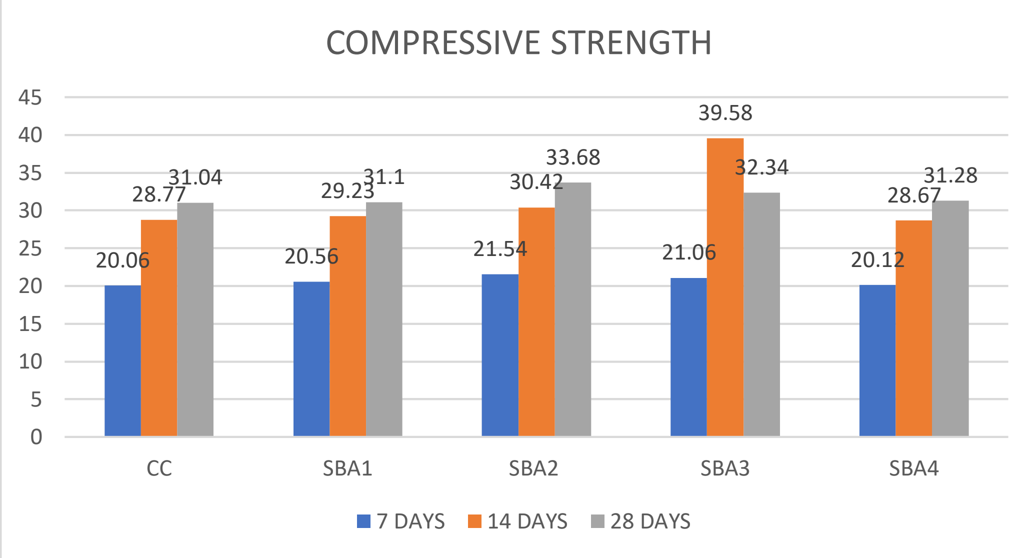

Fig 6 compressive strength result

8.2. SPLIT TENSILE STRENGTH TEST RESULT

The test is conducted on Compression testing machine of capacity 2000 KN. The cylinder is placed horizontally between the loading surfaces of compression testing machine and the load is applied till failure of the cylinder. The Split tensile strength is represented in the following table 8

Table 8 Split tensile strength result

Mix Designation	Mix proportion				Split Tensile strength N/mm^2
	Cement	River sand	Sugarcane bagasse ash	Coarse aggregate	28 Days
CC	100%	100%	0%	100%	3.43
SBA1	95%	100%	5%	100%	3.51
SBA2	90%	100%	10%	100%	3.68
SBA3	85%	100%	15%	100%	3.46
SBA4	80%	100%	20%	100%	3.28

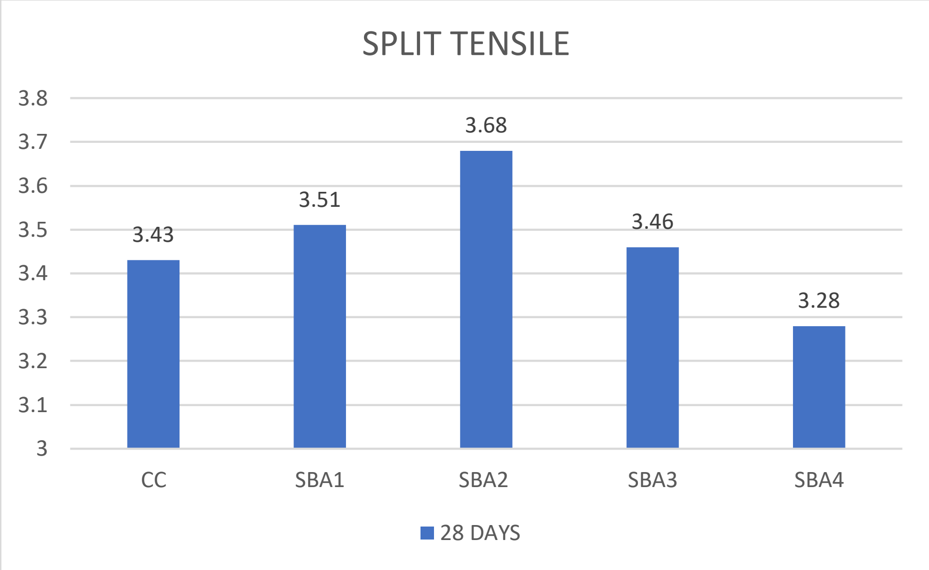

Fig 7 Split tensile strength result

8.3. FLEXURAL STRENGTH TEST RESULT

Flexural strength of the concrete was tested as per IS :516-1959 using the prism of size 100mmX100mmX500mm and the results were given in the Table 9

Table 9 flexural strength test result

Mix Designation	Mix proportion				Flexural strength N/mm^2
	Cement	River sand	Sugarcane bagasse ash	Coarse aggregate	28 Days
CC	100%	100%	0%	100%	4.12
SBA1	95%	100%	5%	100%	4.23
SBA2	90%	100%	10%	100%	4.56
SBA3	85%	100%	15%	100%	4.38
SBA4	80%	100%	20%	100%	4.27

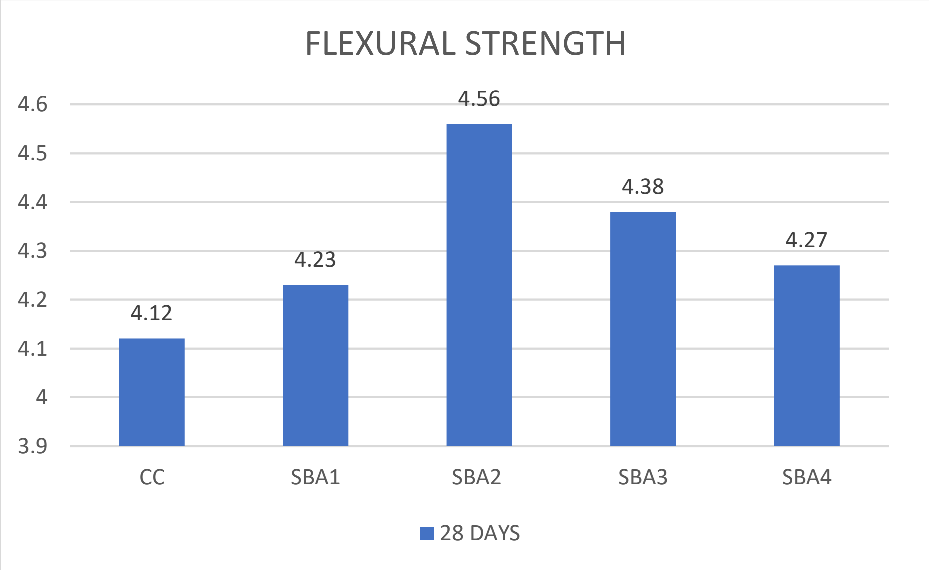

Fig 8 flexural strength test result

CONCLUSION

1. Sugarcane bagasse ash concrete performed better when compared to ordinary concrete up to 10% replacement of sugarcane bagasse ash.

2. Increase of strength is mainly to presence of high amount of silica in sugarcane bagasse ash. It also enhances the properties.

3. It makes the concrete more durable. Sugarcane bagasse ash added to the mixes rate in cement reduced. Bagasse ash in concrete reduces the environmental pollution.

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