Experimental Investigation on Partial Replacement of Cement by Using Sugarcane Bagasse Ash

D. Dinesh Kumar [1], A. Ayyappan [2], S.Dhivagar [3], B.Dineshkumar [4], P.Marimuthu [5], V.Prasanth [6]
[1,2]Assistant Professor, Shivani Engineering College, Tiruchirapalli-620 009, Tamil Nadu, India.
[3, 4, 5, 6] UG Students of Shivani Engineering College, Tiruchirapalli-620 009, Tamil Nadu, India.

Abstract – India produces around 24-25 MEGATON of sugar these days and also same is approximately the estimated sugar cane bagasse ash (SCBA) produce of India. Therefore it is essential that a useful method of utilization of this sugr factory waste should be found and gainfully used. As the demand and consumption of cement raising, researchers and scientist are in search of developing alternates binders that are eco friendly and contribute towards waste management .The utilization of industrial and agricultural waste produced by industrial processes has been focus of waste reduction research for economic, environmental and technical reasons. Sugar cane bagasse ash is a fibrous waste product of the sugar industry, along with ethanol vapor. This waste product is already causing serious environmental pollution , which calls for urgent ways of handling the waste. Bagasse ash is mainly contains aluminium ion and silica. It has limited life span and after use it s either stock piled or sent to landfills. In these project bagasse ash has been chemically and physically characterized and partially replaced in the ratio of 0%,5%,10% and 15% by weight of cement fresh concrete that is slump cone test were undertaken as well as hardened concrete test is compressive strength and Split Tensile Strength at the age of 7,14 and 28 days was obtained.

Index Terms – sugar cane bagasse ash (SCBA), Megaton, ethanol vapor.

1. INTRODUCTION

It used the waste of material to forming the environmental pollution and the material are reused by the waste at include the concrete.The control of the environmental pollution, land waste to the controlled, the reusing mater many studies were carried out on the utilization of sugarcane bagasse ash obtained from the controlled burning of raw husk as per the procedure laid down in the literature and most of the studies are focused on the improvement of physical and chemical properties of sugarcane bagasse ash in concrete. Only a few studies have been reported on the use of sugarcane bagasse ash partial replacement in cement. Very little information is available on the chloride impermeability and corrosion resistant properties of concrete blended with these ash. In this research work, an experimental investigation for the evaluation of sugarcane bagasse ash and prepared from the mill residues as cement replacement materials and assessment of optimal level of replacement to the blended cement concrete system for the strength and resistance against chloride penetration and corrosion of steel are considered.

Ordinary portland cement is recognized as a major construction material throughout the world. Researchers all over the world today are focusing on ways of utilizing either industrial or agricultural waste, as a source of raw materials for industry. This waste, utilization would not only be economical, but may also result in foreign exchange earnings and environmental pollution control. Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as Supplementary cement replacement materials. Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in electric generation industry. When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties. A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement. It is also used in concrete without adverse effects in concrete durability. Therefore it is possible to use Sugarcane Bagasse Ash (SCBA) as cement replacement material to improve quality and reduce the cost of construction materials such as mortar, concrete pavers, concrete roof tiles and soil cement interlocking block. The present study was carried out by Partial Replacement of Cement by SCBA of sugarcane bagasse.

1.1CHEMICAL PROPERTIES OF SUGARCANE BAGASSE ASH

1. The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses and 25% of lignin.

2. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash.

3. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO2).

4. 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.

5. (SCBA) Its Colour having Black & Specific Gravity- 1.306

TABLE1.1 CHEMICAL COMPOSITION OF SUGARCANE BAGASSE ASH

Sl.No	COMPOSITION	Mass%
1	Silica dioxide(SiO2)	66.89
2	Aluminaoxide(AI2O3)+Iron Oxide(Fe2O3)	29.181
3	Calcium Oxide(CaO)	1.952
4	Magnesium Oxide(MgO)	0.82
5	Sulphur Tri Oxide(SO3)	0.56
6	Loss of Ignition	0.72

1.2 RESEARCH SIGNIFICANCE

The construction of modern structures calls for materials with increasingly improved properties like strength, stiffness, toughness, ductility and last but not least durability. It is essential that when concrete is use for modern structures, then it should retain its original form, quality and serviceability throughout its lifespan without any deterioration that is, it should have long durability. Durability of concrete depends on strength of concrete also. Strength is defined as ability of concrete to carry load. Now-a-days concrete with varieties of strength are available as per requirements. Cost of concrete too varies with strength. Even though strength is a key factor, only limited studies are carried out to investigate the addition of Sugar Cane Bagasse Ash (SCBA). In this study, therefore we firstly an attempt has been to study the effect of addition of Sugar Cane Bagasse Ash and which gives the maximum strength on test result on compression strength of low grade concrete (M25).

1.3 OBJECTIVES WORK

1. The present study aims at mix design of M25 grade of concrete and to find required constitutes of it.

2.The study the effect of replacement of cement in concrete by pozzolonic material that is Bagasse Ash.

3. To study the effect of addition of Sugar Cane Bagasse Ash (0%, 5%, 10%, and 15%) on compressive strength of low grade concrete (M25).

4. To find out the optimum percentage of Bagasse Ash that can effectively replaces the cement by weight without any adverse effect on properties of hardened concrete.

2. LITRATURE REVIEW

IJCSE-International Journal of Civil & Structural Engineering ResearchPiyushkumar ,Anil pratapsingh(2015);They studied on " Effect of use of Bagasse Ash on Strength of Concrete", with increasing demand and consumption of cement ,researchers and scientist are in search of developing alternate binders that are eco friendly and contributes towards waste management .In these paper SCBA has been chemically and physically characterized and partially replaced in the ratio of 0%,5%,10%,15%&20% by weight of cement in concrete. The properties for fresh concrete are tested like slump cone test and for hardened concrete compressive strength at the age of 7&28 days by using grade M30.The test result indicate that the strength of concrete increase up to 10% SCBA replaced with cement.

IJSLE-International for Service Learning In Engineering R Shrinivasan and K. Sathiya (2010); They studied on "Experimental Study on Bagasse Ash in Concrete". The utilization of industrial and agricultural waste produced by industrial processes has been the focus of waste reduction research for economic, environmental, and technical reasons. Sugar-cane bagasse is a fibrous waste-product of the sugar refining industry, along with ethanol vapour. This waste product (Sugar-cane Bagasse ash) is already causing serious environmental pollution, which calls for urgent ways of handling the waste. Bagasse ash mainly contains aluminium ion and silica. In this paper, Bagasse ash has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 15% and 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 tests like compressive strength, split tensile strength, flexural strength and modulus of elasticity at the age of seven and 28 days was obtained.The test result indicate that the strength of concrete increase up to 15% SCBA replacement with cement.

Sirirat Janjaturaphan and Supaporn Wansom (2010); They studied on, "The Pozzolonic Activities of Industrial Sugar Cane Bagasse Ash". They find out the chemical composition of the Sugarcane Bagasse Ash and compared them with the other pozzolonic material that is, rice husk ash and concluded that the SCBA is suitable for the partial replacement of cement.

D. Mukharjee (2011) Has Study made on "Utilization of SCBA". They described the various uses of SCBA in agriculture, construction, use of bagasse as fertilizers; in horticulture etc. their chemical and other fertilizing properties etc. also gave various options for utilizing bagasse ash in various fields. Ashes obtained after control burning of SCB at 600oC/5hour were reasonably reactive given by the fact that little crystallization of minerals occurred. Morphological, XRD and TGA/DTA study of the blended pastes confirmed the hydration reaction of SCBA within the cement gel. Compressive and flexural strength tests confirmed the actual behaviour of SCBA blended mortars and it suggested that up to 15% substitution of OPC with SCBA can be made with better strength results than that with pure cement.

K Meeravali, K V G D Balaji, T. Santhosh Kumar (2014);They studied on, "Partial Replacement of Cement in Concrete with Sugar Cane Bagasse Ash-Behaviour in Hcl Solution". In this paper concrete cubes are casted with different percentages of

Sugarcane Bagasse ash replaced with cement by weight (i.e. 0%, 5%, 10%, 15%, 20%, and 25%), and this cubes are exposed to 5% HCL environment. Compressive strength of cubes for 7days, 28 days and 60days are observed. Having gone through above literatures, it has been found that several researchers studied the effect of SCBA with their thermal and mechanical properties on concrete. Higher grade of concrete was considered as a base sample for above all research. So an attempt has been made to find out the % of SCBA to be added to M20 grade concrete in order to increase its strength and make it competition with higher grade concrete with maintaining the economy of work.

Sagar W. Dhengare, Dr.S.P.Raut, N.V.Bandwal, AnandKhangan(2015);they Studied on, "Investigation into Utilization of Sugarcane Bagasse Ash as Supplementary Cementations Material in Concrete". This paper presents the use of sugarcane bagasse ash (SCBA) as a pozzolanic material for producing high-strength concrete. The utilization of industrial and agricultural waste produced by industrial processes has been the focus on waste reduction. Ordinary Portland cement (OPC) is partially replaced with finely sugarcane bagasse ash. The concrete mixtures, in part, are replaced with 0%, 10%, 15%, 20%, 25% and 30% of SCBA respectively. In addition, the compressive strength, the flexural strength, the split tensile tests were determined. The bagasse ash was sieved through No. 600 sieve. The mix design used for making the concrete specimens was based on previous research work from literature. The water –cement ratios varied from 0.44 to 0.63. The tests were performed at 7, 28, 56 and 90 days of age in order to evaluate the effects of the addition SCBA on the concrete. The test result indicate that the strength of concrete increase up to 15% SCBA replacement with cement.

3. METHODOLOGY

3.1 INTRODUCTION OF MATERIALS USED AND PRELIMINARY INVESTIGATION OF MATERIALS:

Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space between the aggregate particles and glues them together. We can also consider concrete as a composite material that consists essentially of a binding medium within which are embedded particles or fragments of aggregates. The simplest representation of concrete is:

Concrete = Filler + Binder.

For this kind of concrete, the composition can be presented as follows

Cement → Cement paste + Water + → mortar +aggregate → concrete

The material using in this investigation.

a) CEMENT: Mostly used cement in concrete is Ordinary portland Cement.These cement gains compressive strength with age.[1489-1991]

b) COARSE AGGREGATE : The crushed aggregate used were 20mm and 10mm nominal maximum size &tested as per Indian Standard and result are within permissible limit(IS:10262,IS:383) Specific gravity =2.71 ,Fineness Modulus = 6.814) Fine aggregate are purchased which satisfied the required properties of fine aggregate required for experimental work and the sand conforms to zone II as per the specifications of IS 383:1970. Specific gravity = 2.63, Fineness modulus = 2.84, Silt content=2.63

c) WATER: Mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportions. In this project clean potable water is used and curing as per IS: 456-2000.

d) BAGASSE ASH : The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemi cellulose and 25% of lignin. This material contains amorphous silica which is indication of cementing properties.

Figure 1: Sugarcane Bagasse Ash

4. MIX DESIGN OF CONCRETE MIXES WITH VARYING PERCENTAGE OF SUGARCANE BAGASSE ASH:

Mix design is the process of selecting suitable ingredient if concrete and determines their relative proportions with the object of certain minimum strength and durability as economically as possible.

4.1 FACTORS TO BE CONSIDER IN MIX DESIGN

1. Grade of concrete

2. Type of cement

3. Type & size of aggregate

4. Type of mixing & curing

5. Water /cement ratio

6. Degree of workability

7. Density of concrete

8. Air content

Test For a one concrete mould of M25 preparation (concrete cube of size 150x150x150mm) following quantity of material are required. M25 = 1:1:2 proportions ,Volume = 0.15x0.15x0.15 = 3.375 x10^{-3} m3

a)BAGASSE ASH

0%, 5%, 10% and 15% of cement adopted Slump Cone Testing , Compression Testing , Split Tensile Testing.

4.2 CASTING AND CURING

We are going to cast standard cube of size 150x150x150mm.Casting will be done by varying percentage of SCBA. After casting, curing will be done. Testing of cube after 7days 14days and 28days will be done.

4.3 TESTING OF CAST SPECIMEN TO OBTAIN COMPRESSIVE STRENGTH

After curing, testing on the cubes will be in two stages i.e.Stage 1: After 7 days of casting. Stage 2: After 14 days of casting. Stage3: After 28day of casting.

4.4 TEST ADOPTED

1. Slump Cone Testing

2. Compression Testing

3. Split Tensile Testing

4.5 SPECIFIC GRAVITY OF COARSE AGGREGATE

The container is dried thoroughly and it's weight W_1 grams. Take 200grams of the coarse aggregate and it's weighed again with container W_2gams. The sufficient water is added to cover the coarse aggregate half full and is screwed on the top. It is shaking well and stirred thoroughly with the glass rod to remove to entrapped air.

After the air has been removed container is completely filled with water up to mark. The outside of the container is completely filled with up to mark is dried with a cloth and weighted W_3grams.The container is cleaned thoroughly. The container is completely filled with water up to top. The outside of the container is a dried with a clean cloth and it is weighted W_4grams.

Specific gravity of Coarse aggregate = $\frac{(W2-W1)}{(W2-W1)-(W3-W4)}$

TABLE1.1 SPECIFIC GRAVITY OF COARSE AGGREGATE

Sl.NO	DETERMINATION	VALUE (Kg)
1	Weight of empty bottle(W_1)	0.658
2	Weight of empty bottle + Coarse aggregate(W_2)	1.340
3	Weight of empty bottle +Coarse aggregate + Water(W_3)	1.868
4	Weight of empty bottle + Water(W_4)	1.485

CALCULATION

$$\text{Specific gravity} = \frac{(W2-W1)}{(W2-W1)-(W3-W4)}$$

$= (W2 - W1)$

$= (1.340 - 0.658)$

$= 0.682$

$= (W3 - W4)$

$= (1.868 - 1.485)$

$= 0.383$

$=\frac{(0.682)}{(0.682)-(0.383)}$

$= 2.84$

Specific gravity of Coarse aggregate = 2.84

4.6 WATER ABSORPTION TEST ON COARSE AGGREGATE

1.The coarse aggregate passing through Is 10 mm sieve is taken out 200g.

2. They are dried in oven at a temperature of 110' ± 5' fix 24 hours.

3. The coarse aggregate is cooled to room temperature. It weight is taken out (W1g)

4. The dried coarse aggregate is immersed in clean water at a temperature 27'± 5' for 24 hours.

6. The coarse aggregate is remove from water and witted out of traces of water with a cloth.

7. With in three minutes from removal of water, the weight of coarse aggregate (W2) is find out.

Table1.2 Water Absorption Test on Coarse Aggregate

SL NO	Weight of oven dried specimen (W1g)	Weight of saturated specimen (W2g)	Weight of water absorbed W3=(w2-w1)g	Percentage of water required (w3/ w1)×100
1	200	202	2	1

CALCULATION:

Weight of water absorbed = (W2 - W1)
= 202 - 200
= 2g

Percentage of water required = (W3/W1)×100

= (2/200) × 100

Percentage of water required = 1%

in Coarse aggregate.

4.7 SPECIFIC GRAVITY OF FINE AGGREGATE

1. The pycnometer is dried thoroughly and taken it's weighed as W_1gram.

2. Take one third part of sand in pycnometer, weighed it as W_2gram.

3. The pycnometer is filled with water up to the top.

4. Then it's shaking well and stirred thoroughly with the glass rod to remove the entrapped air.

5. After the air has been removed, the pycnometer completely filled with water up to the mark.

6. Then outside of the pycnometer is dried with a clean cloth and it's weighed as W_3grams.

7. The pycnometer is cleaned thoroughly. The pycnometrer is completely filled with water up to top.

8. Then outside of the pycnometer is dried with a clean cloth and it's weighed as W_4gram.

Specific gravity of

Fine aggregate = $\frac{(W2-W1)}{(W2-W1)-(W3-W4)}$

Table1.3 Specific Gravity Of Fine Aggragarte

Sl.NO	DETERMINATION	VALUES (Kg)
1	**Weight of empty bottle(W_1)**	**0.660**
2	**Weight of empty bottle +Fine aggregate(W_2)**	**1.312**
3	**Weight of empty bottle + Fine aggregate + Water(W_3)**	**1.927**
4	**Weight of empty bottle + Water(W_4)**	**1.554**

CALCULATION

Specific gravity = $\frac{(W2-W1)}{(W2-W1)-(W3-W4)}$

$= (W2 - W1)$

$= (1.312 - 0.660)$

= 0.652

$= (W3 - W4)$

$= (1.927 - 1.554)$

= 0.373

$=\frac{(0.652)}{(0.652)-(0.373)}$

= 2.64

Specific gravity of Fine aggregate = 2.64

4.8 SPECIFIC GRAVITY OF CEMENT

1. The Flask should be free from the liquid that means it should be fully dry. Weight the empty flask(W1).

2. Fill the cement on the bottle up to half of the flask (about 50gm) and weight with its stopper (W2).

3. Add Kerosene to the cement up to the top of the bottle. Mix well to remove the air bubbles in it. Weight the flask with cement and kerosene(W3).

4. Empty the flask. Fill the bottle with kerosene up to the top and weigh the flask(W4).

Specific gravity of Cement = $\frac{(W2-W1)}{(W2-W1)-(W3-W4)\times 0.75}$

Table1.4 Specific Gravity Of Cement

Sl.NO	DETERMINATION	VALUES (g)
1	Weight of empty flask(W_1)	22.26

2	Weight of empty flask + Cement(W_2)	31.50
3	Weight of empty flask + Cement + Kerosene(W_3)	48.40
4	Weight of empty flask + Kerosene(W_4)	43.07

CALCULATION

Specific gravity = $\frac{(W2-W1)}{(W2-W1)-(W3-W4)\times 0.75}$

$= (W2 - W1)$

$= (31.50 - 22.26)$

= 9.24

$= (W3 - W4)$

$= (48.40 - 43.07)$

= 5.33

$=\frac{(9.24)}{(9.24)-(5.33)\times 0.75}$

= 3.15

Specific gravity of Cement = 3.15

4.9 CONSISTENCY OF BAGASSE TEST

1. Weight of 400 grams of Bagasse on to a non- porous plate form and make it into a depression in to hold the mixing bar

2. Find out the volume of water to give a percentage of 25 by weight of dry cements and this amount carefully to the Bagasse.

3. Mix the Bagasse and water together thoroughly the process of mixing shall include kneading and threading. The total time elapsed from the amount of moment adding water to the Bagasse and mixing completely shall not be less then 4 minutes.

4. Fill the mould completely with the cement paste so gauged and strike off the top level with the top of the mould, slightly shade the jar and mould with the Bagasse to drive to entrapped air.

5. Keep the mould under the vicat plunger and supporting the moving ring by the plunger of the dash pot release the rod.

6. After the plunger has come to rest, note the reading against the index.

7. Repeat the experiment with trial plate of varying percentage of water fill the plunger comes to rest between 5mm to 7mm from the bottom used.

Table 1.5 Consistency Of Bagasse Test

SLNO	**Weight of Bagasse water cement ratio(gm)**	**Percentage of water content added (ml)**	**Debth of penetration (mm)**	**Amount of water required**
1	400	25	40	100
2	400	27	32	108
3	400	29	28	116
4	400	31	15	124
5	400	33	2	132

CALCULATION

Amount of water required = $\frac{\text{Weight of cement} \times \text{\% of water required}}{100}$

1. $\frac{400\times 25}{100} = 100$ m

2. $\frac{400\times 25}{100} = 108$ ml

3. $\frac{400\times 25}{100} = 116$ ml

4. $\frac{400\times 25}{100} = 124$ ml

5. $\frac{400\times 25}{100} = 132$ ml

The standard consistency to the Bagasse = 33%

5. RESULT COMPARISION

a) Compressive Strength Test:

Figure 3: Final crack on concrete

The compressive testing machine was used to test the entire concrete strength at 7, 14 and 28 days respectively. The compressive strength for concrete grade M25 (1:1:2) were investigated for the control mix and while cement was partially replaced by Sugarcane Bagasse Ash. The results of compressive strength test at different curing periods are provided in table. Through the laboratory observation it was perceived that early age strength is lower than the later age strength, because concrete gain its strength with the passage of time.

Table 5.1 Compressive strength of concrete for M25

Ordinary Portland cement replacement with SCBA %	Compressive strength (N/mm^2)			Average compressive strength (N/mm^2)		
	7 days	14 days	28 days	7 days	14 days	28 days
	7.1	13.3	28			
0	8	15.5	28.8	7.8	14.5	28.1
	8.4	14.6	27.5			
	8.8	16.4	28.4			
5	9.7	14.6	28.8	9.7	16.1	29.1
	10.2	17.3	29.7			
10	9.7	15.5	30.2			
	11.1	16.8	31.5	10.8	17.03	31.4
	11.5	1.6	32.4			
	7.5	13.3	28			
15	9.3	15.5	29.3	8.4	15.2	28.2
	8.4	16.8	27.5			

GRAPH

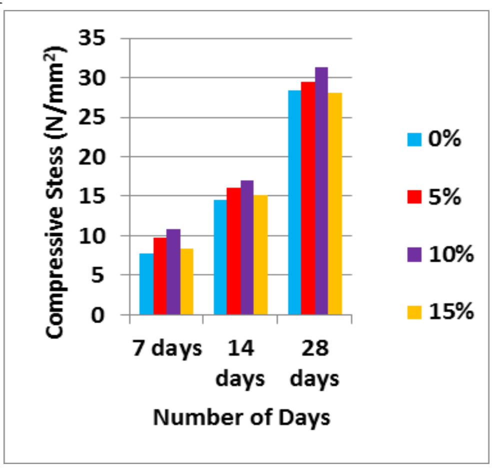

Figure 4: This graph represent compressive strength on concrete

b) Split Tensile Stress

For split tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast. The split tensile strength concrete is determined by casting cylinder of size 150mmX300mm. The cylinders were tested by placing them uniformly. Specimen were taken at age of 28 days of moist curing tested after surface water dipped down from the specimens. This test was performed on the Universal Testing Machine (UTM).

The magnitude of tensile stress (T) acting uniformly to the line of action of applied loading is given by formula,

$$T_{sp} = \frac{2P}{\pi d l}$$

TABLE 5.2 Split Tensile Stress of Concrete

SL NO	% REPLACEMENT OF SCBA	7 DAYS N/mm^2	14 DAYS N/mm^2	28 DAYS N/mm^2
1	0	1.52	2.33	2.90
2	5	1.34	2.50	2.96
3	10	1.94	2.98	3.40
4	15	1.23	2.36	2.78

GRAPH

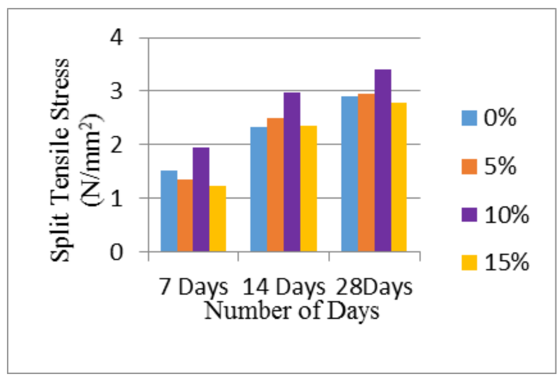

Figure 5: This graph represent Split Tensile Strength on Concrete

6. CONCLUSION

This research was successfully carried out, to the establishment of SCBA as an alternative cement replacement material in concrete. After the detailed investigation the following conclusions have been drawn: SCBA in concrete gives the higher compressive strength as compared to the normal strength concrete, hence optimal results were found at the 10% replacement of cement with SCBA. The usage of SCBA in concrete is not only a waste-minimizing technique, also it saves theamount of cement.The replacement of cement with SCBA increases the workability of fresh concrete; there fore,use of super-plasticizer is not essential.

It is recommended that future research should be performed to assess the use of SCBA in concrete for several properties of concrete for,Slump cone test, Compressive strength test, split tensile test.

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