A STUDY ON THE CONCRETE USING SUGAR CANE BAGASSE ASH WITH COAL BOTTOM ASH

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ABSTRACT

The researches has shown that every one ton of cement manufacture releases half ton of carbon dioxide, so there is an immediate need to control the usage of cement. On the hand materials wastes such as Sugar Cane Bagasse Ash(SCBA) is difficult to dispose which in return is environmental Hazard. 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.

This project mainly deals with the replacement of cement with Bagasse ash in fixed proportions and analysing the effect of magnesium sulphate on SCBA blended concrete. The concrete M30 mix designed by varying the proportions of Bagasse ash for 0%, 5%,7%,10% &12% the cubes were casted and cured in normal water for ages of 7, 14 and 28 days, the properties like slump cone test and compaction factor test for fresh concrete and compressive strength, flexural strength for hardened concrete were verified and results was analysed.

Key words: Sugar Cane Bagasse Ash(SCBA), M30 mix, compressive strength, flexural strength, slump cone test, compaction factor test.

INTRODUCTION

GENERAL

In ancient period, the structures are made from naturally occurring gaps formed between mountains and hills generally known as caves. As the time passes, with increasing population the number of caves occupied is increased. So as to protect the nature, construction of structures has been started. Initially buildings are constructed with the available local materials such as the stones, mud and lime. Later, as the technology improved stones were used in the foundation and the superstructure was constructed with the bricks made of lime and concrete.

Concrete usage around the world is second only to water. Concrete manufacturing involves consumptions of ingredients like cement, fine aggregates, coarse aggregates, water and admixtures. The utilization of concrete is increasing manifold due to developments and subsequent demand for infrastructure and construction activities. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. The environmental issues associated with the production of OPC are well known. The amount of the carbon dioxide released during the manufacture of OPC due to the calcination of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced.

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.

Bagasse ash, which is considered as an industrial waste, if utilized to its maximum capacity in the construction industry, provides the benefits of reducing the Conventional cement generated CO2 as well as saving precious land from becoming a landfill site. Hence, Bagasse ash based concretes have been gaining popularity as an eco friendly construction material and studies are being conducted on its suitability as an alternative to the much popular Portland cement concrete.

OJECTIVE OF THE STUDY:

The present study deals with the partial replacement of Sugarcane Bagasse ash for M 30 grade of concrete.

i) To study the effect of adding different percentages (0%,5%, 7%, 10%&15%) of sugarcane bagasse ash by the weight of cement in the preparation of concrete mix.
ii) To determine the workability of freshly prepared concrete by Slump test & Compaction factor test.
iii) To determine the compressive strength of cubes at 7, 14, 28 days curing
iv) To determine the flexural strength of beams at 28 days curing.

LITERATURE REVIEW

Sugarcane today plays a major role in the worldwide economy and Brazil is the leading producer.The production process generates bagasse as a waste, which is used as fuel to stoke boilers that produce steam for electricity cogeneration. The final product of this burning is residual sugarcane bagasse ash (SCBA), which is normally used as fertilizer in sugarcane plantations. Ash stands out among agro-industrial wastes because it results from energy generating processes. Many types of ash do not have hydraulic or pozzolanic reactivity, but can be used in civil construction as inert materials. Mortars and concretes with SCBA as cement replacement were produced and tests were carried out: compressive strength, tensile strength and elastic modulus. The results indicated that the SCBA samples presented physical properties similar to those of cement. Several heavy metals were found in the SCBA samples, indicating the need to restrict its use as a fertilizer. The mortars produced with SCBA in place of cement showed better mechanical results than the reference samples. SCBA can be used as a partial substitute of cement.

- **Muni Vishwakarma, R.K. Grover**, Student M.E. Structural Engineering, Associate Professor, Civil Engineering Department, Jabalpur Engineering College,Jabalpur conducted study on the strength and cost analysis of concrete with Sugarcane Bagasse ash in the year 2015.The present work focuses on ash for partial cement replacement obtained from agricultural wastes, either by incineration in the laboratory or directly from industries where the waste has been incinerated for energy production. The Sugarcane Bagasse ash mixture provides strength equal to the nominal strength of the concrete and reduces the cost at a large scale.This paper is summarizes the experimental studies on strength of cement mortar with partial replacement of Ordinary Portland cement by Sugarcane Bagasse Ash (SBCA). Cement mortar paste were prepared with various percent of SCBA as partial replacement of OPC in range 5%, to 20 % by weight of cement.

CONVENTIONAL CONCRETE

Concrete is a composite material composed of coarse aggregate bonded together with a fluid cement which hardens over time. In Portland cement concrete (and other hydraulic cement concretes), when the aggregate is mixed together with the dry cement and water, they form a fluid mass that is easily moulded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix which binds all the materials together into a durable stone-like material that has many uses. Often, additives (such as pozzolans or superplasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished material. Conventional concrete was developed using IS method of mix design.

The history and importance of concrete:

The Romans first invented what today we call hydraulic cement-based concrete. They built numerous concrete structures, including the Pantheon in Rome, one of the finest examples of Roman architecture that survives to this day, which a 42-meter diameter dome has made of poured concrete. The name concrete comes from the Latin "concretus", which means to grow together. This is a good name for this material, as the chemical hydration process, which mainly occurs over the time scale of hours and days, causes the material to grow together from a visco-elastic, mouldable liquid into a hard, rigid solid. In our world today, concrete has become ubiquitous, and in fact it is hard to imagine modern life without it. About five billion tonnes of concrete are used around the world each year, enough for close to one tonne for each person per year, at a volume of about 400 litres per person. The cement used mostly in today's concrete is called Portland cement. The process to produce portland cement was invented by Joseph Aspdin in the early 1800's in England. The name portland may have been originally a marketing ploy, as portland building stone was very popular in England at that time, and Aspdin may have wanted people to favourably compare concrete made with his cement to the popular building stone. It is important to remember that cement is the powder that reacts with water to form cement paste, a hard solid material that forms the matrix for the concrete composite. The addition of sand (fine aggregates) that are up to a few millimetres in diameter makes mortar and the addition of rocks (coarse aggregates) of up to a few centimeters in diameter makes concrete. It has always been known that concrete is a porous material, whose properties depend on its pore space. There are many different kinds of pores in concrete, ranging from the air voids that are entrapped in the mixing process, which can be quite large, up to a few millimetres in diameter, to the capillary pores, which are essentially the space occupied by the leftover water from mixing, down to the nanometre-scale pores that exist in some of the hydration products produced by the cement-water chemical reaction.

Properties of Normal Concrete

1. Its slump varies from 1 - 4 inches

2. Density ranges from 140 pcf to 175 pcf

3. It is strong in compression and weak in tension.

4. Air content 1 - 2 %.

5. Normal concrete is not durable against severe conditions e.g. freezing and thawing

USE OF SUGARCANE BAGASSE ASH IN CONCRETE

Sugarcane bagasse ash is a byproduct of sugar factories found after burning sugarcane bagasse which itself is found after the extraction of all economical sugar from sugarcane. The disposal of this material is already causing environmental problems around the sugar factories. On the other hand, the boost in construction activities in the country created shortage in most of concrete making materials especially cement, resulting in an increase in price.

PROCESS TO OBTAIN ASH FROM SUGARCANEBAGASSE

Bagasse Carbonization:

- Bagasse was packed in graphite crucible air tight and placed inside electric control furnace.
- Burnt at temperature of 1200^{o}C for 5hrs to obtain black ash.
- This Bagasse ash is used in the research.
- This carbonated bagasse was collected and burned for 6hours at 600^{o}C.

Figure 1: Sugarcane pulp(Bagasse)

CRYSTAL STRUCTURES OF BAGASSE ASH

- The main composition of bagasse ash is siliceous oxide (SiO) that react with free lime from cement hydration.
- But only un-crystal silica oxide has reactive properties.
- Therefore for determining the amorphous, the specimens were burned at different temperature and duration.

- By using XRD test the crystal amount were investigated.
- Test results show that non-crystalline ash were obtained from bagasse burning in 700°C for 90 minutes and also 800°C at time of 15 minutes.

Figure 2: Sugarcane Bagasse ash

BAGGASE

- Fibrous residue left after crushing and extraction of the juice
- It contains fibre water and small quantity of soluble solids

MATERIALS, SPECIFICATIONS AND PROPERTIES

Materials Used:

Concrete, is a homogeneous mixture of cement, fine aggregates and coarse aggregates derives its strength in the presence of water through hydration. The bonding strength of concrete mainly depends on the cement used and the compressive strength of concrete is derived from the coarse and fine aggregates used.In present experimental work the following ingredients are used.

CEMENT:

Ordinary Portland cement 53 grade is used for the present work. The cement has the property to bind all the ingredients together. The specific gravity of cement was found out in the laboratory and is obtained as 2.54.

Figure 3: Cement

SUGARCANE BAGASSE ASH:

Sugarcane Bagasse ash is the residue from an in-line sugar industry and the Bagasse biomassfuel in electric generation industry.When this waste is burned under controlled conditions, italso 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. Therefore, it is possible to use sugarcane Bagasse ash (SCBA) as cement replacement material to improve quality.

Figure:4 Sugarcane Bagasse

Figure:5 Sugarcane bagasse ash

FINE AGGREGATES

Sieve Analysis:

The operation of dividing a sample of aggregates into various fractions each consisting of particles of the same size is referred as sieve analysis. It is conducted in order to determine the particle size distribution in a sample of aggregate called gradation. The fine aggregates used for making concrete are normally of the maximum size 4.75mm, 2.36mm, 1.18mm, 600 microns,300 microns and 150 microns. Grading pattern of sample is assessed by sieving a sample through the entire sieves mounted one over the other in order of size, with large sieve on the top. The material retained on each sieve after shaking, represents the fraction of aggregate coarser than the sieve. Sieving can be done either manually or mechanically. In manual operation the sieve is shaken giving movements in all possible directions to allow all particles for passing through the sieve and this operation should be continued till such a time that almost no1 particle is passing through the sieve. Mechanical devices are actually designed to give motion in all possible direction; it is a more efficient method. For assessing the gradation by sieve analysis, the quantity of materials to be taken on the sieve is given in the below table.

Table: 1 Determination of zones for Fine Aggregates from IS: 383-1970

Designation of IS Sieve	% Passing for Grade zone-1	% Passing for Grade zone-2	% Passing for Grade zone-3	% Passing for Grade zone-4
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600 microns	15-34	35-59	60-79	80-100
300 microns	5-20	8-30	12-40	15-50
150 microns	0-10	0-10	0-10	0-15

Impact Test:

The test sample of aggregates is filled up to about one-third in the cylindrical mould of the impact testing machine and tamped 25 times. Further quantities of aggregates are struck off using the tamping rod as straight edge. The net weight of aggregates in the measure is determined. The mould is fixed firmly in position on the base of the machine and the hammer is raised above the upper surface of aggregates and allowed to fall freely on it. The test sample is subjected to a total of 15 such blows. The crushed aggregate is then removed from the mould and the whole of it is sieved on 2.36 mm sieve until no further significant amount passes. The fraction retained on the sieve is weighed. Using the formula, the impact value of the coarse aggregates is determined.

Table 2 : Impact Test Values for Coarse Aggregate

Aggregate type	Weight of empty mould (gm)	Wt.of Mould+Aggregates(gm)	Impact Value=Difference in wts/Initial wt x 100
Coarse Aggregate	1908	2457	28.77

Figure 6: Coarse Aggregate

Water:

Distilled water for mixing chemicals and fresh potable water for the purpose of workable mix was used in the experimental work.

Specific gravity of materials used in concrete:

The specific gravity of all the materials has been tested in the laboratory using specific gravity bottle for cement, Pycnometer for fine aggregate and coarse aggregate and the results are as follows:

Step 1: Calculation of Target Mean Strength

$$f'_{ck} = f_{ck} + 1.65\ s$$

Where s = standard deviation

f_{ck} = Characteristic compressive strength at 28 days

f'_{ck} = Target mean compressive strength at 28 days

Standard deviation value for M30 grade concrete = 5.0 N/mm^2

Therefore f'_{ck} = 30 + 1.65 x 5.0

= 38.25 N/mm^2

Step 2: Selection of W/C Ratio

From table 7, W/C ratio obtained is 0.45 and the maximum W/C ratio for plain cement concrete for a severe exposure condition is 0.50.

Hence W/C ratio of 0.45 is taken as a value satisfying both the conditions.

Step 3: Calculation of Water Content

The average nominal size of aggregate taken is 20mm and the water content given in table 8for 20mm aggregate is 186 litres (this is for 50mm slump). (our assumed slump 75mm we need to revised the water content. For 25mm slump → increase 3% water)

Water content: 186 + 3% of 186=191.58 litres.

Therefore, water content obtained is 191.58 litres.

Hence, cement content is **425.73 kg**

Step 5: Volume of fine aggregates and coarse aggregates

Sieve analysis of fine aggregates taken for the experimental work conformed the fine aggregates into zone II and hence volume of coarse aggregate per unit volume of total aggregate obtained is 0.62 from table 9

Step 6: Mix Calculations

- Volume of Concrete = 1 m^3
- Volume of Cement = $\frac{\text{water of cement}}{\text{specific gravity of cement}}$ x $\frac{1}{1000}$

  = $\frac{425.73}{3.14}$ x $\frac{1}{1000}$

  = 0.1355 m^3
- Volume of Water =0.1915 m^3
- Total Volume of Aggregates = 1-(0.1355+.1915)

  = 0.6729 m^3
- Volume of FA = 0.37 x 0.6729

  =0.2489 m^3
- Weight of FA = Volume of FA x Specific gravity of FA x 1000

  =0.2489 x 2.61 x 1000

  =649.63 kg
- Volume Of CA = 0.63 x 0.6729

  = 0.424 m^3
- Weight Of CA = Volume of CA x Specific gravity of CA x 1000

  = 0.424 x 2.83 x 1000

  = 1199.92 kg

Table 3 : Quantities of materials in cement concrete.

Material	Quantity
Cement (grade 53)	425.73Kg/m^3
Water	191.58 liters
Fine aggregate	649.63 kg/m^3
Coarse aggregate	1199.92 Kg/m^3
Water: cement	0.45

The final mix proportions are:

cement: fine aggregate: coarse aggregate= **1: 1.526: 2.818: 0.45**

EXPERIMENTAL INVESTIGATIONS ON CONCRETE

Sugarcane Bagasse Ash Concrete Mix Design:

The mix design chosen for the present experimental work is as given below. The mix for Sugarcane Bagasse Ash concrete of M30 was chosen as cement: fine aggregate: coarse aggregate of 1: 1.526: 2.818 with w/c ratio of 0.45. The individual weight of materials listed in the below table.

- Mass of ingredients required will be calculated for 9 no's cubes assuming 10% wastage
- Volume of the Cube = $9*1.10*(0.15)^3$ =0.0334125 m^3
- Mass of ingredients required will be calculated for 3 no's beams assuming 10% wastage
- Volume of the Beam = $3*1.10*((0.10)^2*(0.50))$ = 0.0165 m^3

Sugarcane Bagasse Ash Concrete Production:

Sugarcane Bagasse Ash concrete production is done using the same equipment as that of conventional cement concrete. The detailed process is as given below

Mixing: The dry components (cement, Bagasse ash, sand and coarse aggregate) are introduced into the pan mixer and mixed thoroughly for 4 minutes initially. Later Water is introduced for proper mixing. Wet mixing is continued for another 2 minutes for uniform mixing of concrete ingredients. Concrete can now be tested for workability.

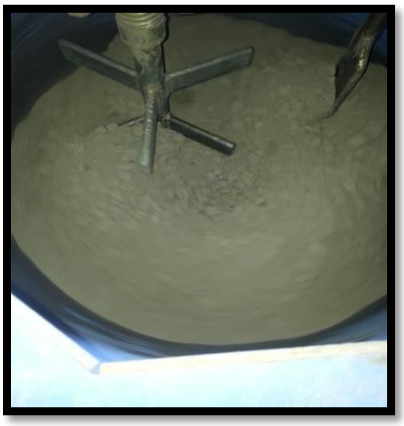

Figure 7: Mixing of SCBA concrete ingredients in pan mixer.

Placing and Compaction: Placing the concrete in cube, beam moulds and compaction by manual. Delay in placing and compaction causes evaporation of water which should be avoided.

Concrete was cast in pre-oiled cast cube iron moulds in 3 layers by tamping each layer with greater then 35 blows and beam iron moulds in 2 layers by tamping each layer with 35 blows. Then the tamped moulds were placed on the vibrator for compaction and surface finished neat.

Figure8: SCBA concrete placed in cube moulds.

Figure 9: SCBA concrete placed in beam moulds.

Figure5.5: SCBA Concrete cubes before drying

Figure10 : SCBA Concrete cubes after drying

Tests on Fresh Concrete

The behaviour of green or fresh concrete from mixing up to compaction depends mainly on the property called "WORKABILITY OF CONCRETE"**.**

Measurement of Workability

The workability of concrete is determined with the help of **SLUMP CONE TEST**. In this test, fresh concrete is filled into a mould of specified shape and dimensions and the settlement or slump is measured when supporting mould is removed.

Figure 11 : Slump Cone apparatus

Figure 12 (a): Slump Test on concrete Figure 12(b): Slump Test of SCBA

The results that are obtained by conducting workability test are mentioned in the following table

Tests on Hardened Concrete

Compressive strength

Concrete cubes of sizes 150mm x 150mm x 150mm are casted by following the Mix design recommendations for both Cement concrete and sugarcane bagasse ash concrete, cured in their respective conditions, and was tested for their 7days, 14days, and 28days compressive strength by using the Compression Testing Machine. This test determines the peak load value that a specimen can withstand before failing. All tests were performed as per guidelines prescribed under IS: 516 -1959.

Figure 13: Cube compression testing on hardened concrete

Test Results for Compressive Strength for M30 conventional concrete

The casted cubes were tested for their compressive strengths at 7days, 14days, 28days respectively and the results are tabulated as follows.

- **Bagasse ash concrete 14 Days Testing**

Sample	Peak Load (KN)	Peak Stress(MPa)
Sample 1	877.28	38.99
Sample 2	910.8	40.48
Sample 3	1046.7	46.52
Average	**944.775**	**41.99**

The test results for 7% replacement of SCBA:

Table:4 Compressive strengths for 7% replacement of SCBA

- **Bagasse ash concrete 7 Days Testing**

Sample	Peak Load (KN)	Peak Stress(MPa)
Sample 1	914.63	40.65
Sample 2	817.43	36.33
Sample 3	898.65	39.94
Average	**876.83**	**38.97**

- **Bagasse ash concrete 28 Days Testing**

Sample	**Peak Load (KN)**	**Peak Stress(MPa)**
Sample 1	1028.03	45.69
Sample 2	1020.6	45.36
Sample 3	983.7	43.72
Average	**1010.7**	**44.92**

The test results for 10% replacement of SCBA

Table:5 Compressive strength for 10% replacement of SCBA

- **Bagasse ash concrete 7 Days Testing**

Sample	**Peak Load (KN)**	**Peak Stress(MPa)**
Sample 1	964.8	42.88
Sample 2	980.1	43.56
Sample 3	958.05	42.58
Average	**967.73**	**43.01**

- **Bagasse ash concrete 28 Days Testing**

Sample	**Peak Load (KN)**	**Peak Stress(MPa)**
Sample 1	1170.9	52.04
Sample 2	1190.48	52.91
Sample 3	1114.88	49.55
Average	**1158.75**	**51.5**

The test results for 12% replacement of SCBA

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Table: 6 Compressive strength for 12% replacement of SCBA

- **Bagasse ash concrete 7 Days Testing**

Sample	**Peak Load (KN)**	**Peak Stress(MPa)**
Sample 1	866.25	38.53
Sample 2	828.45	36.82
Sample 3	796.95	35.42
Average	**778.5**	**36.94**

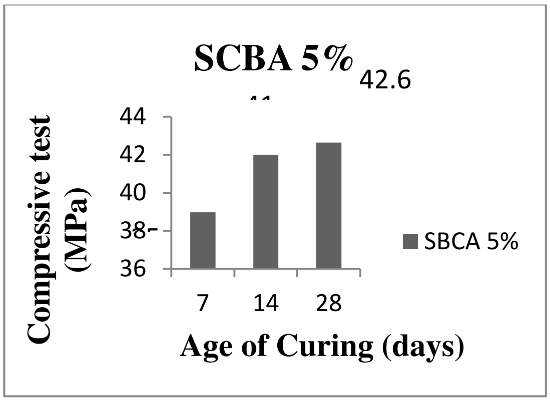
- **Bagasse ash concrete 14 Days Testing**

Sample	**Peak Load (KN)**	**Peak Stress(MPa)**
Sample 1	954.9	42.44
Sample 2	929.03	41.29
Sample 3	920.48	40.91
Average	**934.88**	**41.55**

- **Bagasse ash concrete 28 Days Testing**

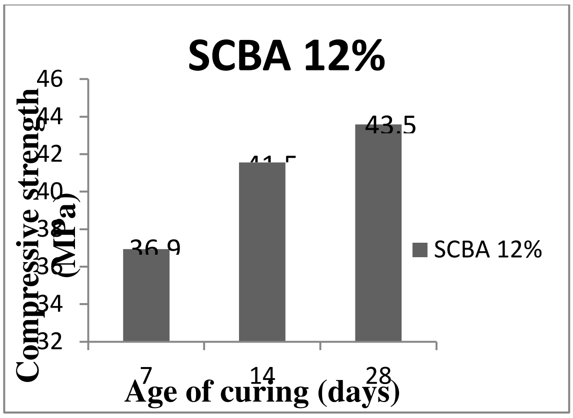
Sample	**Peak Load (KN)**	**Peak Stress (MPa)**
Sample 1	994.5	44.2
Sample 2	994.28	44.19
Sample 3	953.1	42.36
Average	**980.55**	**43.58**

Graph 1: Representing compressive strength of conventional concrete



Graph 2: Representing compressive strength for 5% SCBA replacement

Graph 4: Representing compressive strength for 7% SCBA replacement



Graph 3 : Representing compressive strength for 12% SCBA replacement

5.4.2 Flexural strength(IS:516-1959)

The beam specimens were tested on universal testing machine for two-point loading to create a pure bending. The bearing surface of machine was wiped off clean and sand or other material is removed from the surface of the specimen. The two point bending load applied was increased continuously at a constant rate until the specimen breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. The modulus of rupture depends on where the specimen breaks along the span. Beam dimensions are 500mm×100mm×100mm. if the specimen breaks at the middle third of the span then the modulus of rupture is given by,

b = width of the beam.

Figure 14: Beam flexuraltesting on hardened concrete

RESULTS AND DISCUSSIONS

Test Results on Fresh Concrete

Workability of the concrete mixes, both conventional and sugarcane bagasse ash concrete has been measured using the Slump Cone Test. In both the cases, True Slump was observed and the mixes rendered sufficient workability

Table :7 Slump values for concrete mixes.

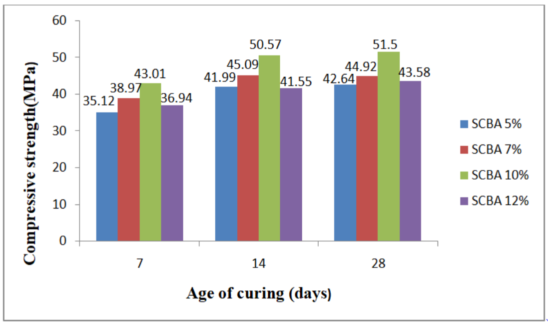
S NO.	Type Of Concrete	Slump Value (mm)
1	Cement Concrete	100
2	Sugarcane bagasse ash Concrete	110

Table: 8 Compressive strength of concrete and replaced concrete (SCBA concrete)

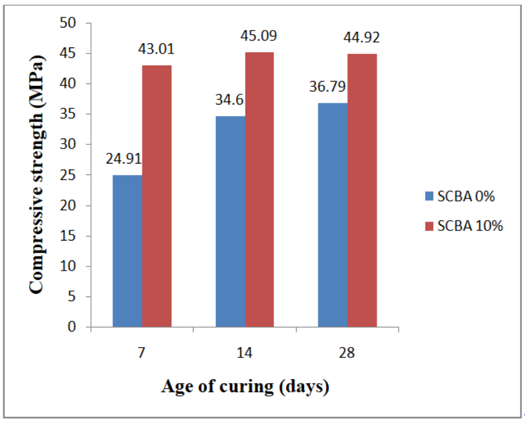
Age of Curing (days)	Cube compressive strength (MPa)				
	Conventional Concrete	SCBA Concrete 5%	SCBA Concrete 7%	SCBA Concrete 10%	SCBA Concrete 12%
7	24.91	35.12	38.97	43.01	36.94
14	34.60	41.99	45.09	50.57	41.55
28	36.79	42.64	44.92	51.50	43.58

Table: 9 flexural strength of concrete and replaced concrete (SCBA concrete)

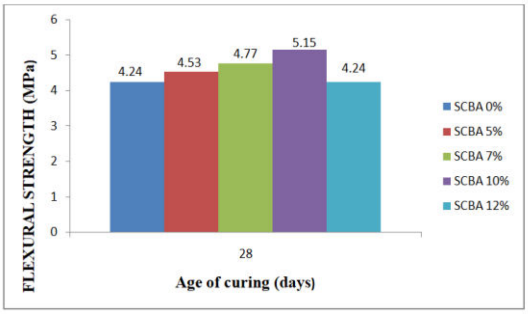
Age of Curing (days)	beamsflexural strength (MPa)				
	Conventional Concrete	SCBA Concrete 5%	SCBA Concrete 7%	SCBA Concrete 10%	SCBA Concrete 12%
28	4.24	4.53	4.77	5.15	4.24



Graph 4 : Representing compressive strength of different percentages of replacement



Graph 5: Comparison of conventional concrete & 10% SCBA replaced concrete



Graph 6: Flexural strength Comparison of conventional concrete & SCBA replaced concrete

CONCLUSION

Result shows that the Sugarcane Bagasse ash in concrete has significantly higher compressive strength compared to the normal concrete without Sugarcane Bagasse ash.

1. In this project, cement is replaced with Sugarcane Bagasse ash with optimum limit of 10%.
2. Results show that maximum strength of concrete was achieved with 10% replacement of cement with Sugarcane Bagasse ash. After that there was decrease in the strength of concrete with increase in the content of Sugarcane Bagasse ash in concrete.
3. This replacement is economical compared to other conventional concrete.
4. Thus, cheaper concrete can be made with industrial waste products for an equivalent strength.
5. Utilization of Bagasse ash in concrete solves the problem of its disposal thus keeping the environment free from the pollution.

FUTURE SCOPE

1. Using Sugarcane Bagasse ash, in addition to cylinderss can also be casted and Split tensile test can be performed respectively.
2. Durability tests like acid test, chloride penetration test and sulphate attack tests can also be performed.
3. Inaddition to SCBA, blended concrete with other pozzolanic materials like silica fume,fly ash etc. can also used to obtain maximum compressive strength.
4. Curing period can also be extended up to 56 and 90 days.

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