EMPLOYMENT OF BAGASSE ASH AS A FRACTIONAL AUXILIARY OF FINE AGGREGATE IN CONCRETE

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ABSTRACT:
Nowadays most of the researches are focusing on ways of utilizing either industrial or agricultural wastes as a source of raw materials for the construction industry. These wastes utilization would not only be economical, but may also help to create a sustainable and pollution free environment. The consumption of industrial and agricultural waste formed 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 vapor. This waste product (Sugar-cane Bagasse Ash) is already causing serious environmental pollution, which calls for urgent ways of handling the waste. Bagasse has mainly contained silica and aluminum ion. In this paper, the Bagasse ash has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 10%, 15% and 25% by the weight of cement in concrete. The bagasse ash was then ground until the particles passing the 90μm sieve size reach about 85% and the specific surface area about 4716 cm^2/gm. Considerable decrease in compressive strength was observed from 15% cement replacement. The test results indicated that up to 10% replacement of cement by bagasse ash results in better or similar concrete properties and further environmental and economic advantages can also be exploited by using bagasse ash as a partial cement replacement material.

Keywords: *Bagasse Ash, Fine Aggregate, CO2, coarse aggregate*

1. INTRODUCTION

The industrial and economic growth witnessed in recent decades has brought with it an increase in the generation of different types of waste (urban, industrial, construction etc.) despite the waste management policies which have been adopted nationally and internationally the practice of dumping and/or the inadequate management of waste from the various manufacturing sectors have had a notable impact on the receiving environment. At the same time, these practices represent an economic cost. However if waste is managed correctly it can be converted into a resource which contributes to savings in raw materials, conservation of natural resources and the climate, and promotes sustainable development.

Sugar cane is one of the most important agricultural plants that grown in India. Bagasse is a byproduct of the sugarcane industry. 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. Despite variety use of bagasse, for production of wood, papers, animal food, compost and thermal insulation, statistics show that about one million tone extra of bagasse ash remains in the country.

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. As the sugar production is increased, the quantity of bagasse ash produced will also be large and the disposal will be a problem.

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.

Development of new concrete additives could produce a stronger, more workable material while reducing the amount of cement required and the resulting CO_2 emissions. Concrete is used in such large amounts because it is, simply, a remarkably good building material not just for basic road construction but also for rather more glamorous projects.Concrete production is responsible for so much CO_2 because making Portland cement not only require significant amounts of energy to reach reaction temperatures of up to 1500^{o}C, but also because the key reaction itself is the breakdown of calcium carbonate into calcium oxide and CO_2. Of those 800kg of CO_2 around 530kg is released by the limestone decomposition reaction itself.

Concrete is the world's most utilized construction material. The need for infrastructure development in both the developing and developed countries has placed great demand on Ordinary Portland Cement (OPC), traditionally, the main binder in the manufacture of concrete. The production of Portland cement as the essential constituent of concrete requires a considerable level and also releases a significant amount of chemical carbon dioxide emissions and other greenhouse gasses (GHGs) into the atmosphere. Thus seeking an eco-efficient and sustainable concrete maybe one of the main roles that construction industry should play in sustainable construction. Despite the advantages of concrete as a construction material, the production of cement comes at a greater cost to the environment. The production of cement requires high energy input (850KCal/Kg of clinker) and implies the extraction of large quantities of raw materials from the earth (1.7tones of rock to produce 1 tone of clinker). On the other hand, the production of 1 tone of cement generates 0.55 tone of chemical CO2 and requires an additional 0.39 tones of CO2 in fuel emissions, accounting for a total of 0.94 tones of CO2. Therefore, the replacement of cement in concrete by bagasse ash represents a tremendous saving of energy and has important environmental benefits. Besides, it will also have a major effect on decreasing concrete costs, since the cost of cement represents more than 45%of concrete cost, also the cost of deposition of bagasse ash in landfill will be saved.

Development of new concrete additives could produce a stronger, more workable material while reducing the amount of cement required and the resulting CO_2 emissions. Concrete is used in such large amounts because it is, simply, a remarkably good building material not just for basic road construction but also for rather more glamorous projects.Bagasse is commonly used as a substitute for wood in many tropical and subtropical countries for the production of pulp, paper and board, such as India, China, Columbia, Iran, Thailand and Argentina. It produces pulp with physical properties that are well suited for generic printing and writing papers as well as tissue products but it is also widely used for boxes and newspaper production. It can also be used for making boards resembling plywood or particle board, called Bagasse board and Xanita board, and is considered a good substitute for plywood. It has wide usage for making partitions, furniture etc.

From previous experimental works, it was found that an optimal amount of 10% of cement can be replaced with bagasse ash. This project presents a detailed study of how cement replaced in concrete performs.

The present study was carried out on SCBA obtained by controlled combustion of sugarcane bagasse, which was procured from the Samalkot in East Godavari district. This study analyzes the effect of SCBA in concrete by partially replacement of cement at the ratio of 0%, 5%, 10%, 15%, 20%, and 25% by weight. The experimental study examines the compressive strength, spilt tensile strength and flexural strength of concrete. The main ingredients consist of Portland cement, SCBA, river sand, coarse aggregate and water. After mixing, concrete specimens were casted and subsequently all test specimens were cured in water at 7 days, 28 days and 90 days.

2 .OBJECTIVE OF THE WORK:

The main objective of the work is studying the effect on the strength on partial replacement of cement with bagasse ash. In this work, we study the comparison between strength variation on NCC and bagasse ash replaced concrete. From the study we can find out how much economy can be attained on using bagasse ash as partial replacement for cement. The objectives of the work are as follows:

- To improve the strength properties of eco-efficient concretes in order to utilize them in major construction projects involving high strength requirements.
- Develop systems to mitigate and ultimately avoid industrial waste material.
- Develop industrial waste management systems.
- Develop ways to use industrial wastes as raw material for making construction material.
- To develop environmental friendly methods of construction.
- To make the best use of industrial waste.
- To establish strategies to find economical means of construction.
- To overcome the problem of waste disposal crisis caused due to industries.
- Determine the ways to utilize industrial waste in most effective, ecological, environmental, social and financially responsible manner.

3. MATERIALS AND THEIR PROPERTIES:

Raw materials required for the concrete use in the present work are

- **Cement**

Table 1 Physical properties of cement

S. No	Property	Test results
1	Normal consistency	29%
2	Specific gravity	3.10
3	Initial setting time	92 minutes
4	Final setting time	195 minutes

Lower the needle gently and bring it in contact with the surface of the test block and quickly release. Allow it to penetrate into the test block. In the beginning, the needle will completely pierce through the test block. But after some time when the paste starts losing its plasticity, the needle may penetrate only to a depth of 33-35mm from the top. The period elapsing between the times when water is added to the cement at the time of which the needle penetrates the test block to a depth equal to 33-35mm from the top is taken as initial setting time. Replace the needle of the Vicat apparatus by a circular attachment. The cement shall be considered as finally set when, lowering the attachment gently cover the surface of the test block, the centre needle makes an impression, while the circular edge of the attachment fails to do so. In other words the paste has attained such hardness that the centre needle does not pierce through the paste more than 0.5mm.

- **Coarse Aggregates**

Table 2.Physical properties of coarse aggregate

S. No	Property	Value
1	Specific gravity	2.69
2	Fineness modulus	3.02
3	Bulk density Loose Compacted	 14 kN/m^3 16 kN/m^3
4	Nominal maximum size	20 mm

- **Bagasse ash**

The sugarcane bagasse ash consists of approximately 50% of cellulose, 25% of hemicelluloses and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO_2). 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 sugarcane harvests. In this sugarcane bagasse ash was collected during the operation of boiler operating in the Nava Bharat Ventures Sugar Factory, located in the Samalkot, East Godavari District, Andhra Pradesh.

Fig.1 Sugarcane Bagasse

Physical properties of bagasse ash

Table-3Physical Properties of Bagasse Ash

Properties	Values
Specific Gravity	2.20
Colour	Black
Density (gm/cm^3)	1.20
Moisture content	6.28%

Chemical properties of bagasse ash

Table-4. Chemical composition of Bagasse Ash

Components	Mass %
Silica as SiO_2	70.5
Calcium as CaO	4.7
Potassium as k_2O	12.16
Iron as Fe_2O_3	1.89
Sodium as Na_2O	3.82
Aluminum as Al_2O_3	1.36
Magnesium as MgO	4.68
Titanium as TiO_2	$<$ 0.06

These values are taken from the Nava Bharat sugar industry located at samalkot

Fig.2 Bagasse Ash

Sugarcane is one of the major crops grown in over 110 countries and its total production is over 1500 million tons. In India only, sugarcane production is over 400 million tons/year that cause about 10 million tons of sugarcane bagasse ash as an un-utilized and waste material. According to the world, Brazil leads the world in sugarcane production in 2011 with a 734 TMT tons harvest. India was the second largest producer with 342 TMT tons, and China the third largest producer with 115 125 TMT tons harvest. The average worldwide yield of sugarcane crops in 2011 was 70.54 tons per hectare.The most productive farms in the world were in Ethiopia with a nationwide average sugarcane crop yield of 126.93 tons per hectare.

- **Fine aggregate**

Table 5. Physical properties of fine aggregate

S. No	Property	Value
1	Specific gravity	3.08
2	Fineness modulus	3.48

3	Bulk density: Loose Compacted	 $14kN/m^3$ $15kN/m^3$
4	Grading	Zone-II

- **Water**

This is the least expensive but most important ingredient of concrete. The quantity and quality of water is required to be looked in to very carefully. In practice very often great control on the properties of all other ingredients is exercised, but the control on the quality of the water is often neglected. Since quality of the water effects strength, it is necessary for us to go in to the purity and quality of water. The water, which is used for making solution, should be clean and free from harmful impurities such as oil, alkali, acid, etc. in general, the distilled water should be used for making solution in laboratories. Water containing less than 2000 milligrams per litre of total dissolved solids can generally be used satisfactorily for making concrete. Although higher concentration is not always harmful they may affect certain cements adversely and should be avoided where possible. A good thumb rule to follow is, if water is pure enough for drinking it is suitable for mixing concrete.

Table 6. Physical properties of water

S. No	Property	Value
1	pH	7.1
2	Taste	Agreeable
3	Appearance	Clear
4	Turbidity(NT units)	1.75

4. MIX DESIGN

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredients of concrete is governed by the required performance of concrete in two states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depending upon many factors, e.g. w/c ratio quality and quantity of cement, water, aggregate, batching, placing, compaction and curing. The cost of concrete is made up of the cost of material, plant and labour. The variation in the cost of material arise from the fact that the cement is several times costly than the aggregates, thus the aim is to produce as lean a mix as possible.

The actual cost of concrete is related to the cost of materials required for producing a minimum mean strength called characteristic strength that is specified by the designer of the structure. This depends on the quality control measures, but there is no doubt that the quality control adds to the cost of concrete. The cost of labour depends on the workability of mix.

4.1 Requirements of concrete mix design

The requirements which form the basis of selection and proportioning of mix ingredients are:

i. The minimum compressive strength required from structural consideration
ii. The adequate workability necessary for full compaction with the compacting equipment available.
iii. Maximum water-cement ratio to give adequate durability for the particular site conditions.

iv. Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

4.2 Mix calculations:

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1 m³

b) Volume of cement = $\frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$

$=\frac{378}{3.10} \times \frac{1}{1000}$

= 0.122 m^3

c) Volume of water = $\frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1000}$

= $\frac{159}{1} \times \frac{1}{1000}$

= 0.159 m^3

d) Volume of admixture = Nil

e) Volume of all in aggregate = [a – (b + c + d)]

= 1-(0.122+0.159)

= 0.719m^3

f) Mass of coarse aggregate = e × Volume of CA × Specific gravity of CA x 1000

= 0.719 × 0.64 × 2.69 × 1000

= 1238 kg

g)Mass of fine aggregate = e × Volume of FA× Specific gravity of FA × 1000

= 0.719 × 0.36 × 3.08 × 1000

= 797 kg

5. TEST RESULTS:

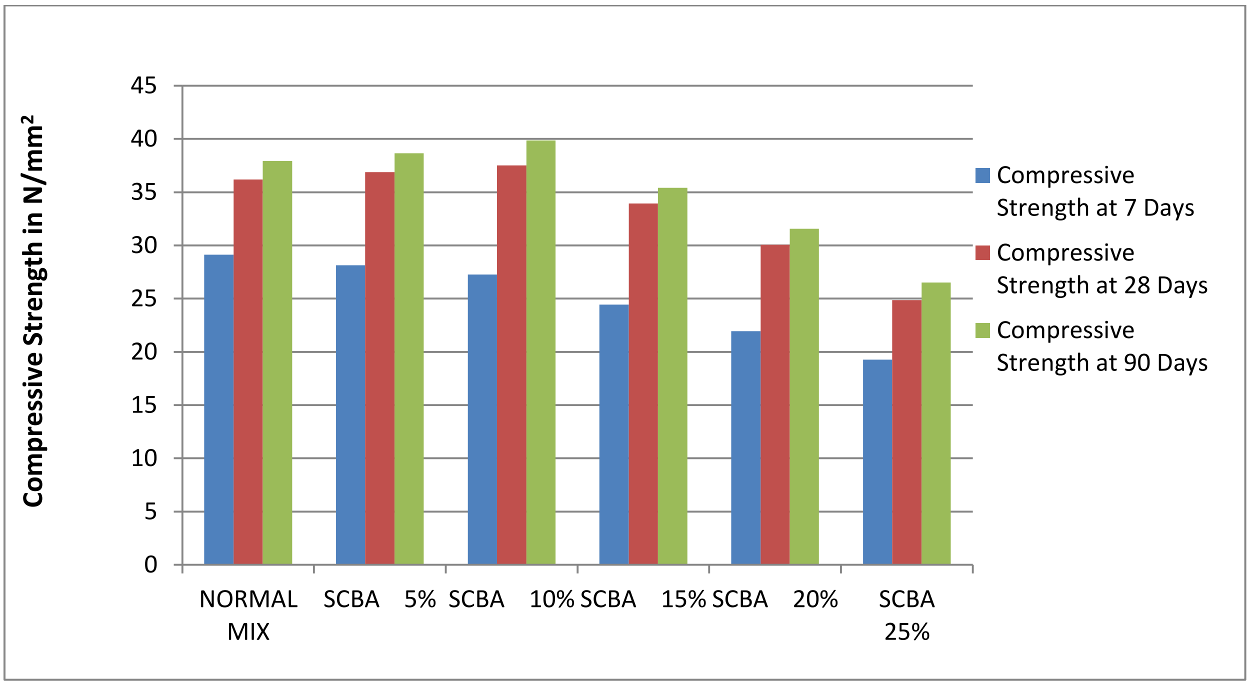
The test results such as compressive strength, split tensile strength and flexural strength of hardened concrete of M25 grade replacement of cement with bagasse ash in the ratio of 0%, 5%, 10%, 15%, 20% and 25% proportions mixes at the ages of 7 days , 28 days and 90 days are detailed. Compressive strength of concrete tested on cubes at different partial replacement of bagasse ash was tested in water curing tank and the test results were shown in below.

Compressive strength:

The compressive strength of the concrete was done on 150 x 150 x 150 mm cubes. A total of 54 cubes were cast for the five mixes. i.e., for each mix 9 cubes were prepared. Testing of the specimens was done at 7 days, 28 days and 90 days, at the rate of three cubes for each mix on that particular day. The average value of the 3 specimens is reported as the strength at that particular age The compressive strength test was conducted for all the mixes and the results are shown in the table below.

Table 7. Compressive strength test results

S.No	Mix id	Compressive Strength (N/mm^2)		
		7 Days	28 Days	90 Days
1	NORMAL MIX	29.13	36.18	37.93
2	SCBA 5%	28.15	36.89	38.67
3	SCBA 10%	27.26	37.52	39.85
4	SCBA 15%	24.44	33.93	35.41
5	SCBA 20%	21.93	30.07	31.56
6	SCBA 25%	19.26	24.85	26.52



Graph 1. Compressive Strength vs age

The compressive strength values obtained by testing standard cubes made with different proportions of SCBA 0%-25%. The normal mix has strength above the 30Mpa in compression.

I was observed that the compressive strength of Normal mix at the age of 7 days is 29.13 N/mm^2. It was observed that compressive strength of SCBA 5% replacement at the age of 7 days has decreased by 3.40% when compared with normal mix, it was observed that the compressive strength of SCBA 10% at the age of 7 days has decreased by 6.52% respectively when compared with Normal mix, it was observed that the compressive strength of SCBA 15% at the age of 7 days has decreased by 16.22% respectively when compared with Normal mix, it was observed that the compressive strength of SCBA 20% at the age of 7 days has decreased by 25.72% respectively when compared with Normal mix, it was observed that the compressive strength of SCBA 25% at the age of 7 days has decreased by 33.89% respectively when compared with Normal mix. It was observed that the compressive strength is gradually decreases from 5% to 25% when compared with the normal mix due to the lateral reaction of pozzolanic property.

It was observed that the normal mix reached its target mean strength (32 N/mm^2), it was observed that the compressive strength of SCBA 5% at the age of 28 days has reached its target compressive strength, however it was observed that compressive strength increased by 2.04% respectively when compared with normal mix, It was observed that the compressive strength of SCBA 10% at the age of 28 days has reached its target mean strength, however it was observed that the compressive strength and increased by 6.55% respectively when compared with Normal mix. It was observed that the compressive strength of SCBA 15% at the age of 28 days has reaches its target mean strength, however it was observed that the compressive strength and decreased by 6.15% respectively when compared with Normal mix, It was observed that the compressive strength of SCBA 20% at the age of 28 days has not reached target mean strength, however it was observed that the compressive strength and decreased by 16.92% respectively when compared with Normal mix, It was observed that the compressive strength of SCBA 25% at the age of 28 days has low compressive strength, however it was observed that the compressive strength and decreased by 34.13% respectively when compared with normal mix. From above all the percentages of replacements observed that the SCBA 10% gives the optimum compressive strength.

It was observed that the compressive strength of Normal mix at the age of 90 days is 37.91 N/mm^2. It was observed that the compressive strength of SCBA 5% has increased by 2% respectively when compared with normal mix. It was observed that the compressive strength of SCBA10% at the age of 90 days has increased by 5.22% respectively when compared with Normal mix. It was observed that the compressive strength of SCBA 15% at the age of 90 days has decreased by 6.6% respectively when compared with normal mix. It was observed that the compressive strength of SCBA 20% at the age of 90 days has decreased by 18.9% respectively when compared with normal mix; It was observed that the compressive strength of SCBA 25% at the age of 90 days has reduced by 38.12% respectively when compared with normal mix.

6. CONCLUSION:

Based on the study, following conclusions can draw.

- There is a change in slump for SCBA 5% has decreased 3.5% when compared with normal mix.
- The slump for SCBA 10%, SCBA 15%, SCBA 20% and SCBA 25% has reduced by 4.7%, 8.2%, 14% and 18.7% respectively when compared with the normal mix.
- The compressive strengths of SCBA mixes at the age of 7 days was gradually decreases its strength when compared with normal mix.
- It was observed that the compressive strength of SCBA 5% and SCBA 10% at the age of 28 days has reached its target mean strength; however the

compressive strength was increased by 2.04% and 6.55% when compared with normal mix.

- It was observed that the compressive strength of SCBA 15%, SCBA 20% and SCBA 25% at the age of 28 days has decreases its compressive strength by 6.15%, 16.92% and34.13% respectively when compared with the normal mix.
- The split tensile strength of mixes SCBA 5% and SCBA 10% at the age of 28 days has increases its strengths by 4.42% and 9.5% respectively when compared with the normal mix.
- The split tensile strength of mix SCBA 15%, SCBA 20%, SCBA 25% at the age of 28 days has decreases it strengths by 11.8%, 24.8% and 32.7% when compared with the normal mix.
- The flexural strength of SCBA 5%, SCBA 10% at the age of 28 days has increases its strength by 4.42%, 9.5% when compared with the normal mix.
- Cement can be replaced with bagasse ash up to 10% without much loss in compressive strength.
- Considerable decrease in compressive strength was observed from 15% cement replacement.
- It has been shown in this study that 10% sugarcane bagasse ash can be used as a partial cement replacement material with technical and environmental benefits. Concerned stakeholder, such as sugar industries, cement industries and relevant government institutions, should be made aware about this potential cement replacement material and promote its standardized production and usage.

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