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COMPARITIVE STUDY OF CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY SUGARCANE BAGASSE ASH

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Abstract: **India is the second largest in major sugarcane producing countries after Brazil. Due to that there is increase in bagasse as a byproduct from the sugar mill. Bagasse is the fibrous residue of sugarcane after crushing and extraction of juice & bagasse ash is the waste product of the combustion of bagasse for energy in sugar factories. Sugarcane bagasse ash is disposed of in landfills and is now becoming an environmental burden. 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. Sugarcane bagasse is a fibrous waste-product of the sugar refining industry, along with ethanol vapor. This waste product (Sugarcane Bagasse ash) is already causing serious environmental pollution, which calls for urgent ways of handling the waste. In this experimental research work, concrete cubes, beams and cylinders of M25 grade with SCBA is tested to examine various properties of concrete like workability, compressive strength, split tensile strength, modulus of elasticity and flexural strength. Sugarcane bagasse ash was partially replaced with cement at 5, 10,15and up to 20 % by weight of cement in concrete. Up to 10 % replacement of cement with SCBA we will get maximum results. Compressive strength , splitting tensile strength, and flexural strength are tested .the study has shown that replacement of sugar cane bagasse ash with cement can be up to 20% by the weight of cement without significant loss in strength of concrete. But the optimum amount of sugar cane bagasse ash that can be replaced with cement is 10% to get maximum strength of concrete. The use of these material which is a waste product is of much benefit in economic, environmental and technical uses.**

I. INTRODUCTION

Concrete is the most commonly used construction material in the world. It is basically components of two components: paste and aggregate. The paste contains cement and water and sometimes other cementitious and chemical admixtures, where as the aggregate contains sand and gravel or crushed stone. The paste binds the aggregates together. The aggregates are relatively inert filler materials which occupy 70%to 80% of the concrete and can therefore be expected to have influence on its properties. The proportion of these components, the paste and the aggregate is controlled by; the strength and durability of the desired concrete, the workability of the fresh concrete and the cost of the concrete.

Cement which is one of the components of concrete plays a great role, but is the most expensive and environmentally unfriendly material. Therefore requirements for economical and more environmental-friendly cementing materials have extended interest in other cementing materials that can be used as partial replacement of the normal Portland cement. Ground granulated blast furnace slag, fly ash, silica fume, etc have been used successfully for this purpose.

Recently Sugarcane Bagasse Ash (SCBA), which is a byproduct of sugar factories found after burning sugarcane bagasse which in turn is found after the extraction of all economical sugar from sugarcane, has been tested in some parts of the world for its pozzolanic property and has been found to improve some of the properties of the paste, mortar and concrete like compressive strength and water tightness in certain replacement percentages and fineness.

The pozzolanic property of SCBA came from the silicate content of the ash. This silicate under goes a pozzolanic reaction with the hydration products of the cement and results a reduction of the free lime in the concrete. The silicate content in the ash may vary from ash to ash depending on the burning and other properties of the raw materials like the soil on which the sugarcane is grown.

Therefore this study attempts to make use of the SCBA produced in Tamil Nadu as a pozzolanic material to replace cement. An experimental investigation was carried out to examine the impact of adding SCBA to the mechanical and physical properties of pastes, mortars and concretes such as consistency, setting time, workability, compressive and flexural strength and durability.

II. OBJECTIVES OF THE RESEARCH

General objectives

- To study the feasibility of using this material found from sugar factories as a cement replacement material.

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- Scope of the study is limited to experiment work with M25 grade concrete

Specific objectives

The specific objectives of this research work can be stated briefly as follows: Evaluating the performance of paste, mortar and concrete made of SCBA as a replacement material by conducting some laboratory tests on the fresh and hardened state and determine the quantity of SCBA that can be successfully. Investigating the economic and environmental issues of using SCBA for cement replacement.

Finally after making such assessment on the performance of the sugarcane SCBA conclusions and recommendations will be forwarded on the performance and various aspects of the material as cement replacement.

III.MATERIALS USED FOR THE RESEARCH

1. Bagasse ash

The use of different cement replacing materials has become a common practice in the construction industry .Most of these cement replacement material are byproducts of different industries and agricultural wastes .Blast furnace slag, silica fumes ,fly ash and risk husk can be sited as an example. Sugarcane bagasse ash also been found to have such pozzolanic property.

Bagasse is a cellulose fiber remaining after the extraction of the sugar-bearing juice from Sugarcane. Bagasse ash is one of the biomass sources and valuable byproducts in sugar milling that often uses bagasse as a primary fuel source to supply all the needs of energy to move the plants. The bagasse ash is about 8-10%of the bagasse and contains unburned matter, silica and alumina.

The bagasse ash used for this research was taken from Bannari Amman Co-operative Sugar Factory which is located in Karnataka. The bagasse ash in this factory is collected at each 8 hour interval from the furnace and dumped around the factory very close to the residence of the factory workers. [5] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller.This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased.

2. Cement

Cement is a fine grey powder which when reacted with water hardens to form a rigid chemical mineral structure which holds the aggregates together acting as glue and gives concrete its strengths

3.Fine Aggregate

M sand was used for experimental purpose. the most important function of the aggregate is to assist in producing workability and uniformity in mixture , the fine aggregate also Assists the cement paste to hold the coarse aggregate particles in suspension. This action promotes the plasticity in mixture and prevents the possible segregation of paste and coarse aggregate particularly when it is necessary to transport the concrete from the mixing plant to point of placement.

4.Coarse aggregate

Coarse aggregates are particles greater than 4.75 mm .but generally range between 9.5 mm to 37.5 mm in diameter .they can either be from primary, secondary or recycled sources, primary, or 'virgin', aggregates are Either land or marine won. Gravel is a coarse marine –won aggregate; land won coarse aggregates include gravel and crushed rock . Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the reminder.

5. Water

Water is an important ingredient of a concrete and it actively participate in chemical reaction with cement. Water which is used for making concrete should be clean and free from harmful impurities such as oil, alkali, acid etc. in general the water which is fit for drinking should be used for making concrete .the ratio of amount of water to the amount of cement by weight is termed as water cement ratio and the strength and quality of concrete primarily depends up on this ratio.

IV. CONCRETE MIX DESIGN STIPULATION

a) Characteristic compressive strength required in the field at 28 days grade designation M25
b) Nominal maximum size of aggregate -20 mm
c) Shape of coarse aggregate-Angular
d) Degree of workability required at site-75-100mm (slump)
e) Degree of quality control available at site –As per IS:456-2000
f) Type of exposure the structure will be subjected to (as defined in IS :456-2000)-Mild
g) Type of cement: OPC 53 grade

Mix proportion 1:1.8:3.2

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V. TEST RESULT AND DISCUSSION

In this section discussion and analysis of laboratory test results of bagasse ash for its suitability as cement replacing materials are presented and analyzed. The different properties of the bagasse ash investigated are:

- The fineness in terms of specific surface area for different replacement of cement with bagasse ash.
- The consistency and setting time of the blended pastes at different replacement contents.
- Specific gravity of cement, fine aggregate and coarse aggregate.
- Strength of mortars containing bagasse ash which replaced OPC.
- The workability and strength (both compressive and split tensile) of concrete.

Fineness test

According to I.S specifications, the standard fineness of cement should be less than 10%. Fineness of the cement without SCBA is 2.2.

Specific gravity of cement with different percentage of replacement by SCBA

Percentage of SCBA	Specific gravity
0	3.15
5	2.8
10	2.9
15	2.8
20	2.7

Consistency of blended pastes
% of SCBA Vs Standard consistency

Water	Cement	Fine aggregate	Coarse aggregate
170	378	697	1197
0.45	1	1.8	3.2

% of SCBA	Percentage of water added	Penetration (mm)	Standard consistency (%)
0	27	18	30
	27.5	15	
	29.5	6	
5	29.5	14	31
	30	10	
	31	5	

Normal consistency of pastes containing bagasse ashes are in table. The control paste or the paste without bagasse ash showed normal consistency of 30%. Alof the pastes containing on the consistency of the blended pastes conformed to previous researches. The increment on water requirement is probably due to the higher fineness of bagasse ash and its porosity as compared to cement.The usual range of water to cement ratio for normal consistency is between 26%and 33%. The pastes with replacement up to 10% showed a consistency with in this range, however, after 10%replacement the results showed slightly higher values.

Setting time of blended pastes

Initial setting time results

% COMPOSITION OF SCBA	INITIAL SETTING TIME(MINUTES)
0	35
5	47
10	48
15	50
20	52

The IS limits the initial setting time of cement not to be less than 30 minutes and the final setting time not to exceed 10 hours. The results for the setting time in Table as the

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bagasse ash content increases the setting time has also showed a trend of increment.

Compressive strength of OPC-BA mortar

The average results for OPC-BA as shown in table.
7 days compressive strength with different percentages of replacement by SCBA

% of SCBA	Load (KN)	Compressive strength (N/mm^2)	Mean compressive strength (N/mm^2)
0	70	14	14.5
	75	15	
5	80	16	16.2
	82	16.4	
10	90	18	18.5
	95	19	
15	80	16	16.3
	83	16.6	
20	70	14	14.2
	72	14.4	

OPC contains a smaller amount of silica by itself. The addition of bagasse ash in this cement had resulted in a higher compressive strength for 5% and 10%replacement. This is probably due to the pozzolanic reaction between the bagasse ash and the $ca(OH)_2$ from the cement hydration.

Different researches also proved the existence of pozzolanic reaction using different advanced methods as stated before.

Specific gravity of Fine Aggregate

Specific gravity of fine aggregate =2.5

Specific gravity of Coarse Aggregate

Specific gravity of Coarse aggregate = 2.67

28 Days compressive strength of cube with different percentages of replacement by SCBA

% of SCBA	Load (KN)	Compressive strength (N/mm2)
0	600	26.6
5	610	27.1
10	670	29.7
15	590	26.2
20	550	24.4

28 days Split Tensile Strength with different percentage of replacement of SCBA

Percentage of SCBA	Load (KN)	Split tensile strength (N/mm2)
0	280	3.96
5	285	4.03
10	300	4.24
15	250	3.54
20	240	3.4

7 days Flexural Strength with different percentage of replacement of SCBA

%e of SCBA	Load (KN)	flexural strength (N/mm2)
0	4.5	2.25
5	4.5	2.25
10	5.5	2.75
15	4.5	2.25
20	4	2

28 days flexural Strength with different percentage of replacement of SCBA

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Percentage of SCBA	Load (KN)	Flexural strength (N/mm2)
0	7	3.5
5	7.5	3.75
10	8	4
15	7.5	3.75
20	6	3

VI. ENVIRONMENTAL ADVANTAGES

The cement industry releases about one tone of CO_2 for each tone of Portland cement production. In addition to this concrete consumes vast amount of natural resources for aggregate and cement production. Replacing the portion of Portland cement with SCBA can substantially reduce the environmental impact of concrete. The most significant environmental factors are virgin material use an emissions.

Virgin Material Saving

Using SCBA, which is a recycled material, will save a great deal of virgin materials. This is because when inventorying the materials that are used to manufacture concrete, only the virgin materials are included in the comparative calculations not recovered materials (i.e. SCBA), because recovered materials already exist and would be disposed if not productively utilized.

Different assumptions were made in order to get the virgin material saving. This are as follows:

- The mass of the raw materials to manufacture Portland cement is assumed to be 1.6 times as much as the mass of finished Portland cement.
- 5 % wastage was assumed for the SCBA production, even though only transportation and grinding is involved.

Economical Advantage

The detail cost break down and economical analysis of the cost advantage of using SCBA was not analyzed because of the variability and unavailability of the necessary data required .However, the economic advantage of using SCBA as a cement replacing material can be made qualitatively. The process is mainly classified into three, the raw material preparation process, the clinker burning process and the finish grinding process. Off all this process, clinker burning is the most energy intensive process, accounting for about more than 90 % of the fuel consumed and about 30 % of the electric power consumption and the rest about 40 % of the electric power is consumed by the finish grinding process and about 30 % by the raw material preparation.

Fuel costs are a large part of the manufacturing cost of the cement industry, making cement plants to have aggressive energy consumption. Moreover, the clinker burning process as shown above take more than 90 % of the fuel consumption, implying that it is the most expensive part of the cement production. From this research work it was found that about 10 % replacement of cement by SCBA results in a comparable concrete characteristics in strength, durability and workability. The production cost of SCBA is much lower than that of Portland cement. This is because the production of SCBA requires only transportation and grinding. This implies that, using SCBA to the minimum totally reduces the cost of clinker production by 10 % (if 10 % replacement is chosen), not mentioning the raw material preparation and other costs associated with cement production.Therefore from the above stated evidences an economical advantage can be exploited by using SCBA as a cement replacing material in many countries.

VII. CONCLUSION

The use of SCBA as a cement replacing material in concrete production was studied and after the research work is done, the following conclusions were made:

1. The fineness of cement even after replacing with SCBA was within the IS limits. As the SCBA which passed through 90 micron sieve was used
2. The specific gravity test reveals that the SCBA from Bannari Amman sugar factory is much lower than that of cement. Thus use of SCBA can result in light weight concrete
3. Higher replacements of cement b SCBA resulted in higher normal consistency and longer setting time.
4. The workability of concrete containing SCBA increases slightly
5. The investigation of this thesis has revealed that replacement of OPC by SCBA from 5 % to 10 % results in better compressive strength than that of control mortar WITH 100 % OPC. And the compressive strength decreases as the SCBA replacement increases over 10 %.
6. The compressive strength results of the concrete have revealed that the concrete with 5 % cement replacement by SCBA have shown a 5 % compressive strength improvement at 28 days over the control concrete with 100 % ordinary Portland cement. The 15 % and 20 % replacements have shown 3.4 % and 12.6 % reduction at 28 days of the control concrete. Therefore up to 10 % we can say

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that there is no strength reduction, which is also shown in the mortar work.

7. Finally the results of this research work have revealed that cement could advantageously be replaced with SCBA up to 10 %. This replacement helps in similar concrete properties to that of control concrete.

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