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An Experimental Study on Properties of Concrete by Partial Replacement of Cement with Sugarcane Bagasse Ash and Glass Powder

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ABSTRACT

Objectives: There are increase in demand and utilization of cement and many scientists are in search for developing alternative binding materials that can be eco-friendly. The use of agricultural and industrial waste produced can help in reduction of waste is our focus. Methods: In this work one of the agricultural waste named sugarcane bagasse ash (SCBA) and industrial waste named glass powder has been used as partial replacement of cement. SCBA is produced by burning of sugarcane bagasse which is left after extraction of juice from sugarcane. At high temperature under controlled condition bagasse is burned to obtain ash which contains high amorphous silica. In this paper the cement by weight is replaced by 0%, 5%, 10%, 15%, 20% and 25% by SCBA in concrete. Findings: A comparison is made for 0% and other percentages by conducting different tests named compressive strength test, flexural strength test and split tensile strength test for 7 days and 28 days. Improvements: The test results shows that Sugarcane Bagasse Ash and glass powder can be utilized for partial replacement of cement up to 10% by weight of cement without any major loss in strength.

KEYWORDS: *Agricultural Waste, SCBA, Concrete, Silica Content*

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INTRODUCTION

Concrete is being widely used for the construction of most of the building, bridges and other structures and it also known as backbone to the infrastructures development of a nation. At present for a variety of reasons, the concrete industry is not sustainable. Firstly it consumes huge amount of natural resource due to which no virgin material will be left for future generation. Secondly the major component of concrete is cement. A large amount of greenhouse gases will be emitted in the manufacturing process of cement. Thirdly, concrete structures suffer from a durability problem due to which natural resources are wasted therefore; there is a need to find an alternative method so that concrete industry becomes sustainable.

The cement produces about 5% of CO2 emissions of the world. About 900kg of CO2 for every 1000kg of cement produced. Hence, currently the entire construction industry is in search of a suitable and effective waste product that would considerably minimize the usage of cement in construction filed and it ultimately reduces the construction cost. Attempts have been equally made by various researches to reduce the cost of the materials used in the concrete and hence reducing total construction cost by investing and ascertaining the benefits of the materials which are termed an agricultural land industrial waste. Some of the waste materials are fly ash, quarry dust, sugarcane bagasse ash, and rice husk ash and glass powder.

In the past, sugarcane bagasse ash (SCBA) and glass powder (GP) were disposed into the nature. This created a several environmental and health concerns. The sugarcane bagasse ash is obtained from the sugarcane industry and glass powder is also a industrial waste. Instead of disposing these materials into land fills they can be effectively used in the production of concrete as a supplementary to the cement. Both sugarcane bagasse ash and glass powder are rich in silica content and also have sufficient amount of calcium content. Hence the waste materials like sugarcane bagasse ash and glass powder can be used in the partial replacement of cement in concrete production.

OBJECTIVE OF THE STUDY

- To investigate the best mix proportion for the partial replacement of sugarcane bagasse ash and glass powder for cement by the different strength values obtained for different sample specimens.

- To investigate the feasibility of the partial replacement of sugarcane bagasse ash and glass powder in concrete by determining its compressive strength.
- To find the optimum percentages of sugarcane bagasse ash and glass powder to obtain the optimum compressive strength values.
- To reduce the cost of major materials used in concrete by replacing it with cheaper materials such as sugarcane bagasse ash and glass powder.
- To increase the strength and durability of concrete by using suitable replacement materials.

The percentage of sugarcane bagasse ash and glass powder which has to be replaced by the weight of cement is as follows shown in table 1.

TABLE I

Sample	SUGARCANE BAGASSE ASH	GLASS POWDER
A	**0**	**0**
B	**5**	**10**
C	10	10
D	15	10
E	20	10

DESCRIPTION OF THE MATERIALS USED

The material used in the present study are cement, fine aggregate, coarse aggregate, sugar cane bagasse ash, glass powder and water.

CEMENT

Cement is a well known binding material which has occupied an indispensable place in the construction works. Cement is a finally powdered material which by itself is not a binder; it develops the binding property as a result of hydration. Cement is called a hydraulic product; the hydraulic products are stable in aqueous environment.

Nowadays high strength portland cement 53 grade is used for the construction works. It has confirmed to the requirements of Indian standard specifications IS 12269-1997. The tests on cement has been carried out as per IS 4031-1991.The chemical composition of cement is given in the table 1. And the physical properties that are obtained by conducting tests on cement is given in table 2.

Chemical composition of ordinary Portland cement

TABLE - 2

CaO	60-67
SiO2	17-25
Al2O3	3-8
Fe2O3	0.5-6
MgO	2.5
SO3	2-2.5
Other Oxides	5

Physical properties of ordinary Portland cement

TABLE - 3

SL. No	Properties	Results
1	Fineness (%)	2.35
2	Normal consistency (%)	34
3	Specific gravity	3.1
4	Initial setting time (min)	35

FINE AGGREGATE

Normally concrete is prepared by using the mix design. Concrete which has reported in this study is prepared with the different combination of the selected ingredients to suit the requirement has a concrete. The sand is one of the main ingredients use in the preparation of concrete. Fine aggregates are basically the sand that has been obtained from the land or marine environment.

The fine aggregates as per the guidelines of IS 383-1970 is defined as the particles, which will pass through the 4.75 mm IS sieve and the materials retained on 150 micron IS sieve. The natural sand is generally considered to have a lower size limit of 0.07 mm. The fine aggregates containing the materials between the range 0.06 mm and 0.02 mm is considered as silt material. The fine aggregates containing the materials still smaller than the ranger of the silt particles then it is considered as clay material. The natural sand as relatively high hydraulic conductivity value as compared to the different types of fine aggregate materials.

As per the guidelines confirming to IS 383-1970 zoning of fine aggregates, the fine aggregates used in the present experimental investigation belong to the zone. The physical properties of the fine aggregates are determined in the laboratory by conducting the tests confirming the guidelines of IS 2386-Part (3)-1963. The test results which are obtained in the laboratory during the present experimental investigation are shown in the table 4.

TABLE - 4

Sl. No	Properties	Results
1	Specific Gravity	2.60

COURSE AGGREGATE

The coarse aggregate is defined as an aggregate most of which is retained on 4.75 mm IS sieve.

Generally angular aggregates are preferred and used for construction works. The angularity of the coarse aggregates also affects the workability or stability of the mix, which depends on the interlocking of the particles. The physical properties of the coarse aggregates are determined in the laboratory by conducting the tests confirming to the guidelines of IS 2386-Part III and the test results which were obtained by the laboratory are shown in the table 5.

TABLE - 5

Sl. No	Properties	Results
1	Specific Gravity	2.67

WATER

Water is a very important ingredient in the preparation of concrete, as it actively participates in the chemical reaction with the cement during the mixing of concrete. In general the water fit for drinking is suitable for mixing concrete. Impurities in water may affect the initial and final setting time, strength and shrinkage of concrete. It may also have its effect in promoting the corrosion of the reinforcement. It has been estimated that or average water by the weight of cement is required for the chemical reaction in cement compounds. Portable water free from the impurity salts was

used for mixing and curing of concrete blocks. Some water containing sugar would be suitable for drinking but it is not suitable fore mixing the concrete and conversely water suitable for making concrete may not be necessarily fit for drinking.

The water to be used in the concrete work should have the following properties:

- It should be free from adverse amount of soils, solids, alkalis, organic materials and inorganic impurities.
- It should be free from iron, vegetable matter and any other type of substances which are likely to have adverse effect on concrete or reinforcement.
- The water used should be fit for drinking.

SUGARCANE BAGASSE ASH

Sugarcane bagasse ash is a byproduct of sugar factory found after burning sugarcane bagasse which itself is found after the extraction of all economical sugar from sugarcane. In India, approximately about 2.5 Million tons of sugarcane bagasse ash produced every year. The sugarcane bagasse ash is a voluminous material and is an environmental waste sugarcane bagasse ash is non biodegradable waste. The disposal of this material is already causing environmental problems around the sugar factories. On the other hand, the boost in the construction activities in the country created shortage in most of concrete making materials especially cement, resulting in an increasing in price.

In this study, sugarcane bagasse ash was collected from **MAKAVALLY SUGAR FACTORY KR PETE** and its chemical properties were investigated.

The sugarcane collected from the factory was used as a partial replacement for cement in the preparation of M20 grade concrete before the use of bagasse ash, it was oven dried to remove the moisture content in the ash. After oven drying the sugarcane bagasse ash which is passing from 90 micron IS sieve was used in this experimental work. The sugarcane bagasse ash is rich in silica content and also possesses sufficient amount of calcium. The chemical composition of sugarcane bagasse ash is similar to that of cement and the physical properties are also in the comparable range.

In the present experimental work cement is partially replaced by the sugarcane bagasse ash in 0%. 5%, 10%, 15% & 20% followed by a constant percent of glass powder and the concrete blocks were made and the compressive strength of the concrete work determined for 7, 14 &28 days the split tensile strength were determined for 28 days.

Chemical composition of sugarcane bagasse ash is shown in the table 5.

Table - 6

Content	Percentage
SiO2	62.43
Al2O3	4.38
Fe2O3	6.98
CaO	11.8
MgO	2.51
SO3	1.48
K2O	3.53

Physical Properties of Sugarcane Bagasse Ash is shown in the table 7.

Table - 7

Sl. No	Properties	Results
1	Specific Gravity	2.20

GLASS POWDER

Million tons of waste glass is being generated annually all over the world. Once the glass becomes the waste it is disposed as landfills, which is unsustainable as this does not decomposes in the environment. Glass is principally composed of silica and it also possesses sufficient amount of calcium. The waste glass pieces are milled by using milling equipment and then the milled glass is used in concrete as a partial replacement of cement could be an important step towards the development of sustainable infrastructure systems. When the waste glass is milled down to micro size particles, it is expected to undergo pozzolonic reactions with the cement hydrates, forming secondary calcium silicate hydrate. In this present study the chemical properties of glass will be evaluated being non biodegradable in nature, glass disposal has land filled has environmental impacts as the land filling will be expensive. The glass powder is sieved and the particles passing through 90 micron ARE sieve are collected. The glass powder increases the compressive strength of the concrete.

Chemical composition of glass powder is shown in the table 8.

Table - 8

Content	Percentage
SiO2	68.1
Al2O3	0.9
Fe2O3	0.6
CaO	14.5
MgO	1.8
Na2O	12.2
K2O	0.8

Physical Properties of Glass Powder is shown in the table 9.

Table - 9

Sl. No	Properties	Results
1	Specific Gravity	2.66

MIX DESIGN

A. Grade designation: M20
B. Type of cement: OPC 53 Grade
C. Maximum nominal size of aggregate: 20 mm
D. Minimum cement content: 300 Kg/m3
E. Maximum water cement ratio: 0.5
F. Workability: 100 mm (slump)
G. Exposure condition: Mild
H. Degree of supervision: Good
I. Type of aggregate: Crushed angular aggregate
J. Maximum cement content: 450 Kg/m3

CONCRETE MIXES

MIX PROPORTION IS **1:1.7:2.7**

Quantity of materials required for 1 m³

TABLE - 10

SI. NO	Materials	Quantity (Kg/m3)
1	Cement (OPC)	394
2	Fine Aggregate	703
3	Coarse Aggregate	1082
4	Water	197

Mix Proportions per cubic meter in Kg

TABLE - 11

SI. No	Sample	Cement	Sand	CA	SCBA	GP	Water
1	A	394	703	1082	0	0	197
2	B	334.9	703	1082	19.7	39.4	197
3	C	315.2	703	1082	39.4	39.4	197
4	D	295.5	703	1082	59.1	39.4	197
5	E	275.8	703	1082	78.8	39.4	197

Mix Proportion for sample A-E (6 cubes per each sample) in Kg

TABLE - 12

SI. No	Sample	Cement	Sand	CA	SCBA	GP	Water
1	A	8.28	13.8	22.32	0	0	4.14
2	B	7.08	13.8	22.32	0.42	0.78	4.14
3	C	6.72	13.8	22.32	0.78	0.78	4.14
4	D	6.24	13.8	22.32	1.26	0.78	4.14
5	E	5.82	13.8	22.32	1.68	0.78	4.14

DEATAILS OF THE SPECIMENS

TABLE - 13

SPECIMEN	CUBES			CYLINDERS
DIMENSION	(150*150*150) mm			150 mm Diameter & 300 mm height
SAMPLE/NO OF DAYS	7 DAYS	14 DAYS	28 DAYS	28 DAYS
A	2	2	2	1
B	2	2	2	1
C	2	2	2	1
D	2	2	2	1
E	2	2	2	1
TOTAL	10	10	10	5

CASTING, DEMOULDING, AND CURING

Fig. 1

Fig .2

Fig .3

Fig .4

TESTS ON CONCRETE

A. TESTS ON FRESH CONCRETE

1. STANDARD SLUMP TEST

Slump values of all the samples

TABLE - 14

SI. No	Items	A	B	C	D	E
1	Proportion	1:1.7:2.7				
2	Slump	100	97	94	89	85

B. TESTS ON HARDENED CONCRETE

1. COMPRESSIVE STRENGTH

Fig .5

2. SPLIT TENSILE STRENGTH OF CONCRETE

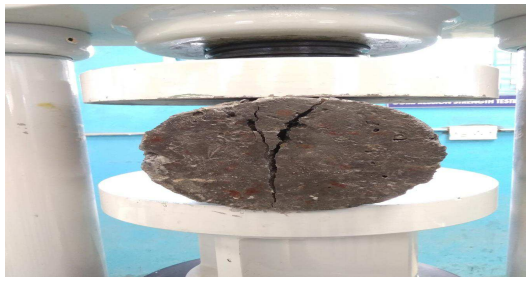

Fig .6

RESULTS AND DISCUSSIONS

A. COMPRESSIVE STRENGTH OF CONCRETE

Compressive Strength of the concrete cubes at 7, 14, & 28 days is shown in table.

TABLE – 15

PERCENTAGE OF REPLACEMENT		COMPRESSIVE STRENGTH (Mpa)		
SCBA	GP	7 DAYS	14 DAYS	28 DAYS
0%	0%	13.99	23.77	26.21
5%	10%	16.22	25.10	26.88
10%	10%	17.55	25.55	27.33
15%	10%	13.10	21.77	24.44
20%	10%	12.24	20.66	23.10

B. SPLIT TENSILE STRENGTH OF CONCRETE

Split tensile strength results at 28 Days are shown in table.

TABLE - 16

PERCENTAGE OF REPLACEMENT		SPLITTENSILE STRENGTH (Mpa)
SCBA	GP	28 DAYS
0%	0%	2.90
5%	10%	3.15
10%	10%	3.50
15%	10%	2.85
20%	10%	2.24

CONCLUSION

Experimental investigation has been carried out to determine utilization of the sugarcane bagasse ash and glass powder as cement replacement materials by making the cement concrete. Based on the results obtained from the experimental work the following conclusions can be drawn:

1. The compressive strength of concrete was higher than the conventional concrete for 10% sugarcane bagasse ash and 10% glass powder replacement by the weight of cement at 7, 14, & 28 days of curing ages. However further increase in replacement percentages lowers the compressive strength of concrete.
2. The split tensile strength of concrete in which cement was replaced by 10% SCBA & 10 & GP was higher than conventional concrete. However further increase in replacement percentages lowers the split tensile strength of concrete.
3. Glass powder and SCBA can be used as partial replacement for cement in concrete which helps in reduction of construction cost.
4. The optimum replacement of cement by SCBA and Glass Powder is 10% and 10%, further increase in the replacement percentages results in reduction of concrete strength.

SCOPE FOR FUTURE WORK

1. Durability of concrete with partial replacement of cement by SCBA and glass powder can be studied.
2. Alkali aggregate reaction of concrete with partial replacement of cement by SCBA and Glass Powder can be studied.
3. Behavior due to acid attack of concrete with partial replacement of cement by SCBA and Glass Powder can be studied.

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