An Experimental Study On Partial Replacement Of Sugarcane Bagasse Ash And Glass Powder In Concrete

[1]Bhagyalakshmi T M, [2]Shilpa S K, [3]R Anil Kumar
[1]Senior Scale Lecturer, [2]Senior Scale Lecturer, [3]Senior Scale Lecturer
[1]Civil Engineering, [2]Civil Engineering, [3]Civil Engineering
[1]Government Polytechnic Arakere, Srirangapatna, Mandya,[2]Govt. Polytechnic, Holenarasipura-573211,[3]Government Polytechnic Nagamangala, Mandya-571432

Abstract:
Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects, and industrial structures to meet the requirements of globalization in the construction field, which involves the construction of buildings and other structures. Concrete plays the key role in the construction field and a large quantity of concrete is being utilized in every construction practices. To increase the strength of concrete the water/cement ratio has to be reduced, which in turn increases the cement content. To overcome low workability problem different kinds of admixtures are used to achieve the required workability.

The sugarcane bagasse ash which is usually disposed can be used as an alternate for cement, since SCBA is rich in silica content and also sufficient calcium content. The SCBA is used in different combination to find the feasibility of using the SCBA as an alternate to cement. The cement is replaced by 0%, 5%, 10%, 15%, and 20% by the weight of cement and by keeping the replacement of glass powder for cement as constant that is 10% by weight of cement. The concrete cubes are casted and compression and split tensile tests were carried out to find the best combination which results in optimum percentage of strength.

Keywords: Cement, Sugarcane bagasse ash (SCBA), Glass powder.

I. 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. 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.

II. CHARACTERISTICS OF MATERIALS

A. Cement

The cement used in this project is ordinary Portland cement which is 53 grade & the name of the cement is Coromandel king.

Fig. 1 Cement

Table 1 chemical composition of ordinary cement

Sl. No.	Contents	Percentage
1.	CaO	60-67
2.	SiO2	17-25
3.	Al2O3	3-8
4.	Fe2O3	0.5-6
5.	MgO	2.5
6.	SO3	2-2.5
7.	Other Oxides	5

Table 2 physical properties of ordinary Portland cement

SL. No	Properties	Results
1	Fineness (%)	2.35
2	Normal consistency (%)	31
3	Specific gravity	2.96
4	Initial setting time (min)	35

B. 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.

Fig. 2 Sugarcane Bagasse Ash

Table 3 Chemical composition of sugarcane bagasse ash

Sl. No.	Contents	Percentage
1.	SiO2	62.43
2.	Al2O3	4.38
3.	Fe2O3	6.98
4.	CaO	11.8
5.	MgO	2.51
6.	SO3	1.48
7.	K2O	3.53

Table 4 Physical Properties of Sugarcane Bagasse Ash

Sl. No	Properties	Results
1	Specific Gravity	2.68

C. 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 decompose 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 pozzolanic 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 landfill has environmental impacts as the land filling will be expensive. Hence it is better to use glass powder as a partial replacement for a cement.

Fig. 3 Glass Powder

Table 5 Chemical composition of glass powder

Sl. No.	Contents	Percentage
1.	SiO2	71.1
2.	Al2O3	0.9
3.	Fe2O3	0.6
4.	CaO	9.2
5.	MgO	4.4
6.	SO3	12.6
7.	K2O	0.8

Table 6 Physical Properties of Glass Powder

Sl. No	Properties	Results
1	Specific Gravity	2.5

III. EXPERIMENTAL WORK

A.Mix Design

Design of M20 grade concrete

Mix Proportions

- Cement = 394 Kg/m3
- Fine Aggregate = 668 Kg/m3
- Coarse Aggregate = 1119 Kg/m3
- Water = 197 Liters
- Water Cement Ratio = 0.5

MIX PROPORTION IS 1:1.7:2.84

B. Details of the Specimens

The details of the specimens are shown in the below table:

Table 7 Dimensions of the test specimens

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**

IV. RESEARCH METHODOLOGY

a) In the present study, we have used concrete cube moulds of size (150*150*150) mm for the compression test & cylindrical moulds of size 150*300 mm for split tensile strength.

b) The specimens are casted for M20 grade concree where cement is partially replaced by sugarcane bagasse ash (0 to 20%) and glass powder (10%).

c) Hand mixing is use for concrete mixing.

d) After casting required specimens, the specimens will be cured by the normal water at the room temperature.

e) After curing the cubes are subjected to compression test for 7, 14, and 28 days & cylinders are subjected to split tensile strength test for 28 days by using compression testing machine at the rate of loading of 140 Kg/cm2 or 14 N/mm2/min as per IS 516-1959.

Casting, Demoulding and Curing

By referring to IS 10262-2009 and IS 456-2000, the mix design is carried out for M20 grade of concrete. The required materials are batched based on the values obtained by mix design. The proportion of cement, sand and coarse aggregate is 1:1.7:2.84. At first the mix design values are calculated for 1 m3 volume and then it computed for standard cube moulds of size 150x150x150 mm & cylindrical moulds of size (150x300) mm. For each fraction of volume of sugarcane bagasse ash and glass powder, two cube moulds are casted and quantities of each materials are calculated for those standard values of the moulds and one cylindrical mould is casted.

Fig. 4 Dry Mix

Fig. 5 Wet Mix

Fig. 6 Casting

Fig. 7 Curing

V. TESTS ON CONCRETE

A. Tests on Fresh Concrete

Standard slump test

The standard slump test is the most well-known and widely used test method to characterize the workability of fresh concrete. The inexpensive standard slump test which measures the consistency, is used on job sites to determine rapidly whether a concrete batch should be accepted or rejected.

Table 8 Slump values of all the samples

SI. No	Items	A	B	C	D	E
1.	**Proportion**	1:1.7:2.84	1:1.7:2.84	1:1.7:2.84	1:1.7:2.84	1:1.7:2.84
2.	**Slump**	100	97	94	89	85

B. Tests on Hardened Concrete

1) Compressive Strength

The compressive strength of concrete that is ultimate strength of concrete is defined as the load which causes failure of the specimen divided by the area of the cross section in the uniaxial compression, under a given rate of loading. To avoid large variation in the result of compression test, great care is taken during the casting of the specimens and while applying load as well. However it is compulsory to conduct the test in uniaxial compression only. Concrete under tri-axial state can offer more resistance and will fail only after considerably large deformations. Compressive testing machine is used to test and determine the compressive strength of the concrete cubes. The formula used to calculate the compressive strength is given below :

Compressive strength (Mpa) = (Failure Load / Cross Sectional Area)

2) Split Tensile Strength of Concrete

The split tensile strength is the ability of the concrete to resist the direct tension. The tensile strength is one of the basic and important properties of concrete. The split tensile strength is determined by using cylinders. The split tensile strength is approximately about 10% of the compressive strength. Concrete is very weak in tension due to its brittle in nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it necessary to determine the tensile strength of the concrete to determine the load at which the concrete cylinders may crack.

VI. RESULTS

A. Compressive Strength of Concrete

Table 9 Compressive Strength of the concrete cubes at 7, 14, & 28 days

TRIALS	PERCENTAGE OF REPLACEMENT		COMPRESSIVE STRENGTH(Mpa)		
MATERIALS	SCBA	GP	7 DAYS	14 DAYS	28 DAYS
SAMPLE A	0%	0%	13.15	18.18	20.09
SAMPLE B	5%	10%	13.33	18.35	20.44
SAMPLE C	10%	10%	13.77	18.69	20.88
SAMPLE D	15%	10%	12.44	16.88	19.40
SAMPLE E	20%	10%	11.88	16.10	18.35

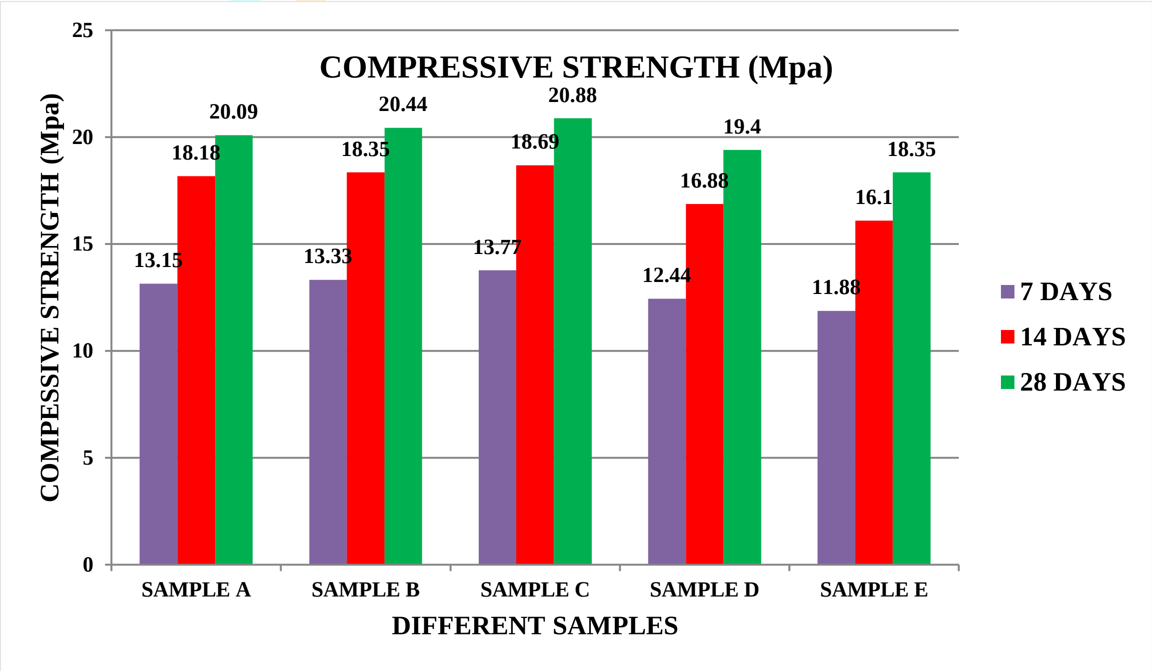

Fig. 8 Comparison between 7, 14 & 28 days Compressive Strength of Concrete

B. Split Tensile Strength of Concrete

Table 10 Split tensile strength results at 28 Days

TRIALS	PERCENTAGE OF REPLACEMENT		SPLIT TENSILE STRENGTH (Mpa)
MATERIALS	SCBA	GP	28 DAYS
SAMPLE A	0%	0%	2.90
SAMPLE B	5%	10%	3.15
SAMPLE C	10%	10%	3.50
SAMPLE D	15%	10%	2.85
SAMPLE E	20%	10%	2.24

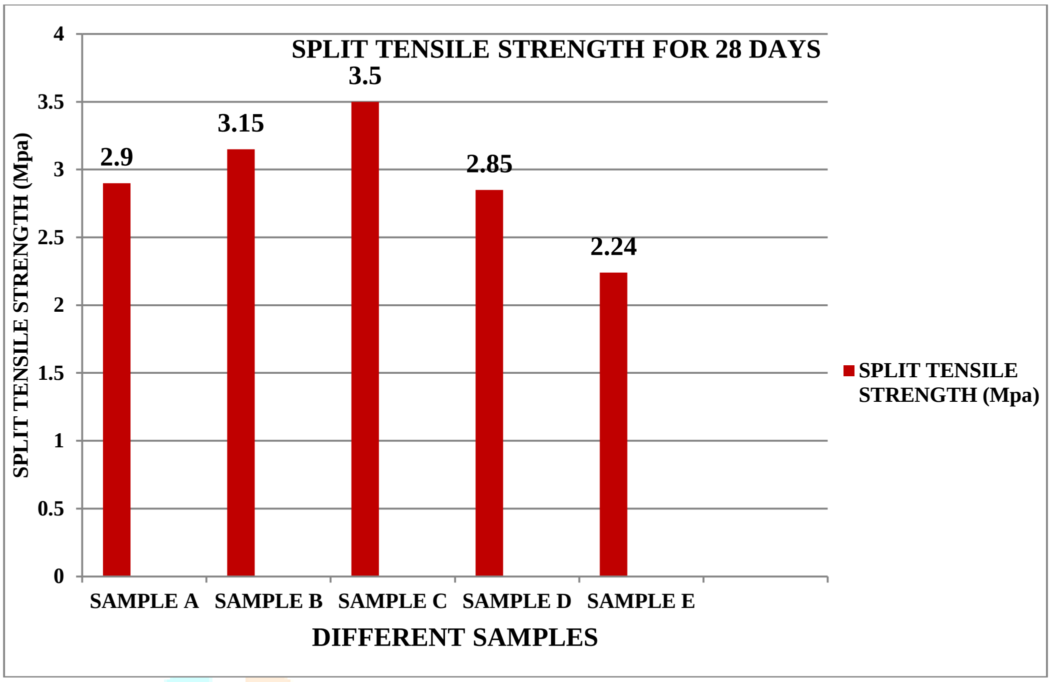

Fig. 9 Graphical representation of 28 days split tensile strength of concrete

VII. CONCLUSION

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. The split tensile strength of concrete in which cement was replaced by 10% SCBA & 10 & Glass Powder was higher than conventional concrete. However further increase in replacement percentages lowers the split tensile strength of concrete. Glass powder and SCBA can be used as partial replacement for cement in concrete which helps in reduction of construction cost. 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.

VIII. REFERENCES

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