RESEARCH ARTICLE

SAMRIDDHI Volume 14, Special Issue 1, 2022 Print ISSN : 2229-7111 Online ISSN : 2454-5767

An Experimental Study on Banana Fibre Reinforced GGBS Concrete

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Abstract

Fibres have been used to reinforce concrete over the last few decades because fibre has significant influence on concrete's static and dynamic properties.Fibre reinforcement into concrete can provide a timely, workableand inexpensiveprocedure for reducingcracking and similar type of deficiencies.Industrial wastes like fly ash,Ground Granulated Blast Furnace Slag (GGBS) etc.,can be utilized as substitution of cement. At the same time, the usage of GGBS as partial substitution of cement will lower the concreterate and helps to decrease cement consumption rate. This paper describes the experimental function on the usage of banana fibre and Ground Granulated Blast Furnace Slag (GGBS) to make better strength and applications of concrete. Banana fibres are extensivelyobtainableeven as agricultural scrap from Banana cultivation. Theyhavekey characteristics like low density, light weight, cheap, high tensile strength, water andfire resistant. They are eco-friendly,inexpensive (zero cost)with chemicals free. The adding of bananafibres considerably improved many attributes of the concrete such as compressive strength, tensile strength and flexural strength. It also increased the potential to withstandrupturing and collapsing of concrete.In this study,banana fibres of four different percentage (0%, 2.5%, 5%, and 7.5%) having length of 40mm and constant percentage of GGBS (2.5%) were used. The banana fibre reinforced GGBS concrete were tested for compressive strength,tensile strength at different ages.

Keywords: Concrete, Banana Fibre,GGBS,Mechanical Properties

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology, (2022); DOI : 10.18090/samriddhi.v14spli01.10

Introduction

Although the sellfor fibre reinforced concrete isquite small-scalein contrast to the gross output of concrete. Globally, the annually consumption of fibres in concrete is 300,000 tons.Concrete containing hydraulic cement, water, aggregate, and discontinuous discrete fibres is called fibre reinforced concrete [1]. Natural fibres are gaining progressive account as renewable, environmentally acceptable, and biodegradable starting material for industrial applications, technical textiles, composites, pulp and paper, as well as for civil engineering and building activities [2]. Natural fibres are generally available from vegetables, animal and mineral sources.Fibres havevarious forms such as coconutfibre, *Musa acuminate* (banana) fibre, steel fibre, glass fibre, jute fibre, synthetic fibre, etc. Banana fibre offers the resistance to suddenly applied loads, limits the shrinkage cracking, decreases the permeability and hence ultimately decreases the bleeding of water [3].

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How to cite this article : Devi, T.M., Shijagurumayum, C., Suresh, T. (2022). An Experimental Study on Banana Fibre Reinforced GGBS Concrete.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology, Volume 14, Special Issue (1), 52-57.

Source of support : Nil

Conflict of interest : None

The development of fibre reinforced concrete (FRC)beginsin the early sixties. When concrete cracks, the randomly oriented fibres start functioning, arrest crack formation and propagation, and thus improve

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strength and ductility [4]. Fibre reinforced concrete scores higher in toughness, and resistance to impact. Reinforcing of fibre into the concrete has added versatility so as to overcome its brittleness. Steelreinforcement reduced the micro cracks developed in the concretehowever,steel becomesrusted because ofvarious actions over a long span of time. This made the need for enlightenment of usage of various organic and inorganic fibres which are eco-friendly and economic [5].The banana fibre is extracted from pseudo-stem. It is used as construction materials in buildings, bridges etc., and also in textile materials. Banana is a fourth most important global food crop [6].

The various construction activities performed at site required several materials such as concrete, steel, bricks, stones, glass, clay, mud, wood, admixtures etc. But cement concrete remains the major construction materials all over the world. During the production of cement, the CO_2 emissions are very high. So, in order to reduce the cement content to avoid CO_2 emissions various industrial wastes like Ground Granulated Blast Furnace Slag (GGBS) which shows similar chemical propertiesto cement can be used as partial replacement of cement [7].GGBS is a by-product of iron and steel industry which is produced in large quantities as a solid waste. It is therefore eco-friendly construction material [8]. The main object of this study is to examine the result of admixtures (GGBS) and banana fibre on the characteristics of concrete and compared it to the plain concrete.

Experimental Programme

The materials required for the present experimental study are:

Cement

Ordinary Portland Cement of 43 grades is used for experimental work.

Fine Aggregate

The fine aggregate was procuredfrom locally available Serou river sand andconfirming to grading zone-III as per IS: 383-1970.

Coarse Aggregate

The aggregates retained in the 4.75 mm sieve after passing 20 mm sieve were selected for this study.

Banana Fibre

The banana fibre was procured from Bangalore, Karnataka. The fibre was cut uniformly to 40mm length.

Figure 1: Banana fibre

Ground Granulated Blast Furnace Slag(GGBS)

GGBS is co-product produced at the same time with iron. The liquefied slag is cooled instantly by putting out in wide volumes of cold water to produceggbs.

Water

The water used for experiments was potable water.

Preparation of Specimen

M20 grade of concrete is used in the present work. The mix proportions for M20 (1:1.5:3) were calculated as per IS: 10262-2009.

A total number of 90 cubes of size 100mmx100mmx100mm, 15 cylinders of size 150mm diameter, 300mm height and are designated as 0F, 2.5F, 5.0Fand 7.5F for the concrete with 0.40 w/c ratio. In all the designations 0, 2.5, 5.0, and 7.5 indicates the % of banana fibre by volume of concrete reinforced in the concrete.

Experimental Investigation

The details of specimens are given in Table-1. C0 is the normal plain concrete specimen. F represents banana fibre reinforced concrete specimen with constant replacement of 2.5% GGBS at different percentages of fibre.

Table-1: Details of Test Specimens

Specimen ID	% of banana fibre	% of ggbs
C0	0	0
F1	0	2.5
F2	2.5	2.5
F3	5	2.5
F4	7.5	2.5

RESULTS AND DISCUSSIONS

Slump Test

This test is carried out to determine the workability of concrete. The slump values are presented in Table-2 . The results shows that the workability of specimen is low i.e., zero slump.

Table-2: Slump Test of Specimens

Specimens	% of banana fibre	Slump value (mm)
C0	0	0
F1	0	0.6
F2	2.5	0
F3	5	0
F4	7.5	0

Compaction Factor Test

Compaction factor test is also performed to determine the workability of concrete. The test results are presented in Table-3.

Table-3: Compaction Factor of Specimens

Specimens	% of banana fibre	Compaction factor value	Quality
C0	0	0.734	Very low
F1	0	0.801	Very low
F2	2.5	0.726	Very low
F3	5	0.705	Very low
F4	7.5	0.680	Very low

From the above results, it is observed that the concrete mix prepared by adding banana fibre shows very low compacting factor. Hence, the banana fibre reinforced concrete mixes are less workable. Workability could be improved by using plasticizers.

Compressive Strength

Compressive strength of specimen after 7 days curing was determined and are shown in Table-4 and Figure 2. The compressive strength for specimen gradually increased with the increase in % of banana fibre added up to 2.5% of banana fibre and then decreased with increase in % of banana fibre.

Table-4: Compressive Strength of Specimens

Specimens	% of banana fibre	Compressive strength (N/mm²)
C0	0	30.11
F1	0	32.44
F2	2.5	35.75
F3	5	33.17
F4	7.5	28.06

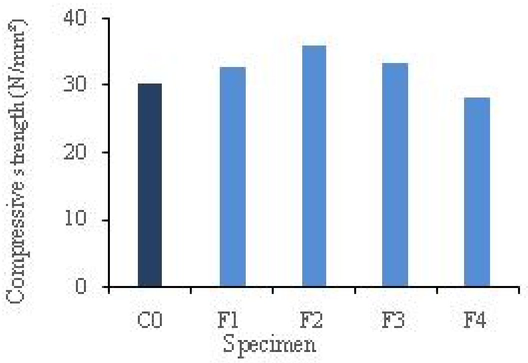

Figure 2: Compressive strength of specimen

The optimum addition of banana fibre with reference tocompressive strength was found to be 2.5%.

Split Tensile Strength Test

The split tensile strength of specimens after 7 days is presented in the Table V and Figure 3. The split tensile strength for specimen slowly increased with the increase in % of banana fibre added till 2.5%. Further increase of banana fibre reduced the split tensile strength.

Table-5: Split Tensile Strength Of Specimens

Specimens	% of banana fibre	Split tensile strength (N/mm²)
C0	0	5.13
F1	0	5.26
F2	2.5	8.27
F3	5	6.67
F4	7.5	6.45

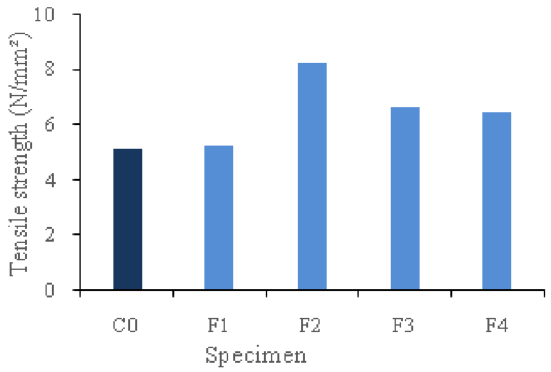

Figure 3: Split tensile strength of specimen

Concrete mix prepared by adding the banana fibre enhances tensile strength as noticed from the results. Banana fibre reinforced concrete results in better tensile strength compared to that of normal plain concrete.

Bulk Density

Bulk density of the specimens is presented in Table VI and also shown graphically in Figure 4. Banana fibre in concrete reduces the bulk density of specimens as evident from the results. Maximum bulk density was obtained from specimen F1 prepared with 2.5% GGBS without banana fibre. The decrease in bulk density with increasing banana fibre can be attributed to its lighter weight and higher porosity

Table-6: Bulk Density of Specimens

Specimens	% of banana fibre	Bulk density (g/mm³)
C0	0	1925.93
F1	0	1983.71
F2	2.5	1955.12
F3	5	1934.91
F4	7.5	1905.88

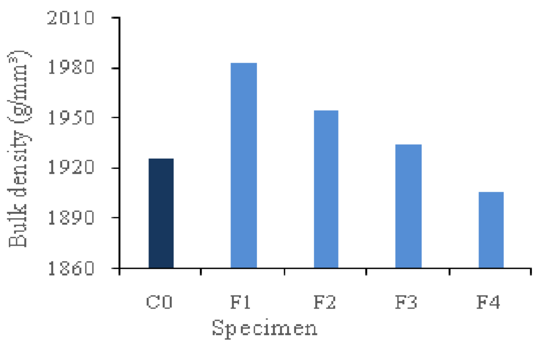

Figure 4: Bulk density of specimen

Water Absorption

This test measured the amount of water that perforate into concrete when immersed.The test results of specimens are as shown in Table-7 and Figure 5.

Table-7: Water Absorption of Specimens

Specimens	% of banana fibre	Water absorption (%)
C0	0	8.21
F1	0	8.15
F2	2.5	7.50
F3	5	10.13
F4	7.5	13.04

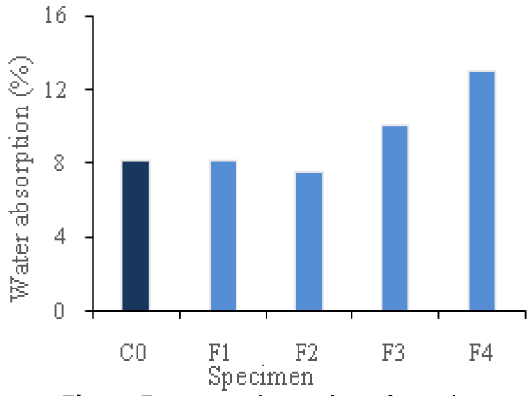

Figure 5: Water Absorption of Specimen

Results indicate higher water absorption in specimens reinforced with banana fibre. Water absorption increases with increasing addition of banana fibre in the concrete specimens. Normal concrete has the lowest water absorption among the specimens. The higher water absorption in banana fibre reinforced specimens should be due to its high porosity. It is therefore necessary to improve the porosity in such specimens by adding suitable admixtures.

Apparent Porosity

This test represents porosity of specimen. The results of apparent porosity for the specimens are shown in the Table-8 and Figure 6.

Table-8: Apparent Porosity of Specimens

Specimens	% of banana fibre	Apparent porosity (%)
C0	0	15.30
F1	0	14.13
F2	2.5	16.11
F3	5	22.01
F4	7.5	24.02

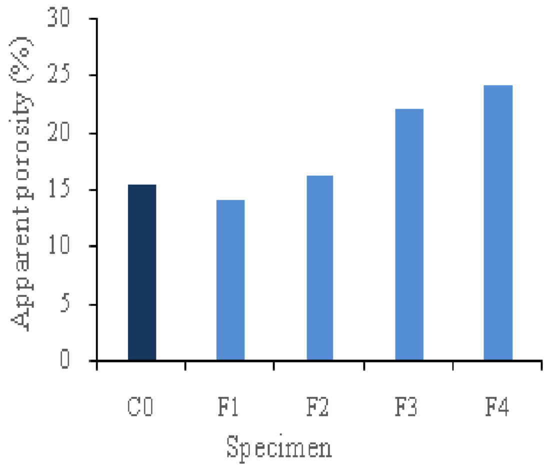

Figure 6: Apparent porosity of specimen

As expected, the apparent porosity increases with increasing banana fibre content in the specimens. However, specimen F1 prepared with 2.5% GGBS without banana fibre performed best among the specimens in terms of porosity. The high porosity of banana fibre reinforced specimen resulted in low bulk density and higher water absorption.

Rebound Hammer Test

This is the test performed to determine the hardness of the concrete surface. It distinguishes three modes of operation. They are impact mode, set-up mode and review mode. The rebound number and the corresponding compressive strength of the cubes are as shown in Table-9 and Figure 8, Figure 7 shows the testing by Rebound Hammer.

Figure 7: Rebound Hammer Test

Table-9: Rebound Hammer Strength of Specimens

Specimens	% of banana fibre	Rebound number	Compressive strength (N/mm^2)
C0	0	42	52.67
F1	0	43	54.33
F2	2.5	34	38.67
F3	5	28	29.00
F4	7.5	26	36.67

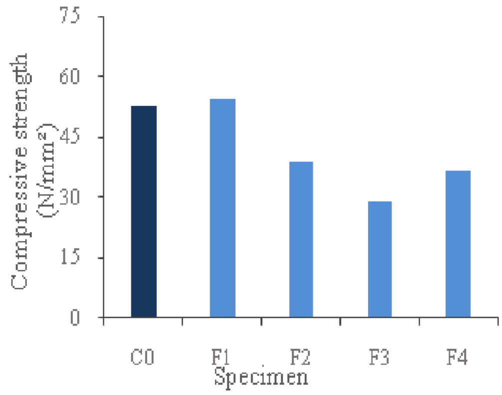

Figure 8: Rebound hammer strength of specimen

From the results, the strength of specimen reduced with the increase in % of banana fibre added. The maximum strength is found at F1 specimen made with no fibre and 2.5% GGBS.

Ultrasonic-Pulse Velocity Test

It is an in-situ test to check the strength and quality of concrete. The instrument used for this test consists of twotransducers (54 kHz), two cables (12 ft.) and coupling agent is used. The results that are obtained for all specimen are as shown in Table-10. The test procedure using UPV is also shown in Figure 9.

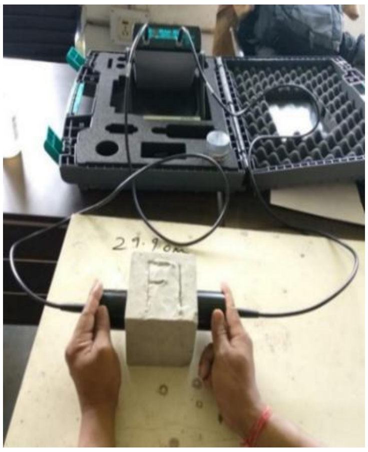

Figure 9: Ultrasonic pulse velocity test

Table-10: Ultra Pulse Velocity Of Specimens

Specimens	% of banana fibre	Pulse velocity (m/sec)	Quality
C0	0	3693	Good
F1	0	3899	Good
F2	2.5	3545	Good
F3	5	3049	Medium
F4	7.5	2959	Doubtful

Thetest value showed the maximum pulse velocity of 3899 at no addition of banana fibres. The results indicate inferior quality of banana fibre reinforced GGBSconcrete specimens in comparison to normal plain concrete.

Conclusion

The inclusion of banana fibres and GGBS into concretenotably improved many characteristics of the concrete such as split tensile strength, compressive strength etc. The concrete mixbecomes less workable when banana fibres are added while the values of slump and compacting factor are low in contrast to normal concrete. The capacityto withstand cracking and spalling are also improved.Although, the banana fibres addition into concreteadversely affected the compressive strength because oflabour in compaction consequently that led to increasevoids.So, fibre reinforced concrete with admixtures have slightly more strength than the normal plain concrete. However, Ultrasonic Pulse Velocity Method gave the remark “good” to both the specimen i.e., normal plain concrete and fibre reinforced concrete with admixtures. At 0% banana fibre addition, the pulse velocity was found to be maximum.

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