RESEARCH ARTICLE

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Study On Partial Replacement of Cement By Ggbs And Natural Sand By Banana Fibre In Concrete

Chirom Iris Devi[1]*, Chitra Shijagurumayum[2], Thokchom Suresh[3]

[1]* Department of Civil Engineering, Manipur Institute of Technology, Imphal, India; e-mail: ririscharm@gmail.com
[2] Department of Civil engineering, Manipur Institute of Technology, Imphal, India.
[3] Department of Civil Engineering, Manipur Institute of Technology, Imphal, India.

ABSTRACT

The rapid development of infrastructure has made it a necessity to adopt some eco-friendly materials. This is because the increasing environmental impact caused by the construction industry has detrimental effect on the environment. The increasing trend of replacing conventional building materials with plant-based fibers has been a major benefit to the environment. This material can be used as a part of the construction process and reduce the impact on the environment. High performance banana fibre reinforced concrete is a type of reinforced concrete that exhibits significant mechanical properties. When banana fibres and GGBS is added to the concrete, it significantly improves the concrete's compressive strength and tensile resistance.Hence this programme was executed to reduce the cost of cement and natural sand in concrete mix of grade M20.It was done by examining the mechanical performance of the concrete mix with partial replacement of cementand sand by GGBS and banana fibre respectively in concrete mix. The compressive strength is increased more effectively with the addition of GGBS instead of cement and the addition of banana fibre gives the better tensile strength to the concrete, therefore the GGBS and banana fibreplays better role in this study.

Keywords : Banana Fibre, Ground Granulated Blast-Furnace Slag (GGBS), Compressive Strength, Tensile Strength, Workability, Water Absorption, Apparent Porosity, Rebound Hammer, Ultra-sonic Pulse Velocity

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INTRODUCTION

The increasing consumption of construction materials in different countries has led the scarcity of natural aggregate become a major issue. This issue can be solved by using artificial aggregates.[1]. The utilization of natural fibres in constructions is due to their properties of being non-abrasive, non-toxic, light weight, biodegradable and low cost. The most purpose of utilizing natural fibres is to reduce the environmental impact of non-biodegradables in composite materials[2]. Portland cement concrete has certain characteristics, such as its tendency to be brittle. It can be strengthened by the addition of certain fibres and conventional steel bar reinforcement. The use of fibres also alters the behavior of the fibre-matrix composite after it has cracked, thereby improving its toughness[3]. Due to the availability of efficient treatment techniques fibres can reliably be used without affecting the concrete properties. So thefibres does not entirely affect the workability of freshly mixed concrete. They have been proved to improve the strength of concrete individually[4].

Concrete is vastly used in construction. However, the constituent materials used in concrete production produces a lot of carbon dioxide emission which

Corresponding Author : Chirom Iris Devi, Department of Civil Engineering, Manipur Institute of Technology, Imphal, India; e-mail: ririscharm@gmail.com

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brings harmful changes to the environment[5,6].Due to the absence of an alternative material which can completely replace the cement, the use of partial replacement of cement has been widely accepted for concrete composite.[6].

A blast furnace is a kind of iron making enterprise that uses limestone, ore of iron and coke. The slag inmolten form, formed inthe blast furnace comprises of silicon dioxide in high percentage and is accordant with the cement's chemical composition. When molten iron is released, the remaining molten iron is quenched with water to form glassy or granular slag[7].

In addition to being used as an ingredient, waste can also be utilized to make new products and contribute to the environment's sheltered from harmful waste[8]. This ultimate focus of this study is to determine the performance of a concrete mix containing GGBS and Banana Fibre and compare it with the normal concrete mix.

EXPERIMENTAL PROGRAMME

The required materials usedfor this programme were cement, GGBS, fine aggregate, banana fibre, coarse aggregate and water.

Cement

The Ordinary Portland Cement (OPC)used for the experiment was43 grade cementwhichconforms to IS 8112-1989.

Fine Aggregate

Locally available Serou river sand conforming to zone II of IS 383-1970 was used in this project work.

Coarse Aggregate

Choosing good quality coarse aggregate is essential for the production of concrete to provide the desired strength and durability requirements. The coarse aggregate used werelocally available with asize of 20mm or lessand hence, the preparation of concrete were made.

Ground granulated blast furnance slag (GGBS)

Ground granulated blast furnace slag (GGBS) were used in concrete to replace cement partiallyin order to achieve better concrete with lower cost. Moreover, GGBS reduce the effects caused by cement environmentally and socioeconomically.

Banana Fibre

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

Water

Water is the key ingredient of concrete as it is the main constituent which enables the chemical reaction of the cement with other constituents making it the most reliable binder in construction industry. Water available in laboratory were used for mixing concrete and curing the specimen.

PREPARATION OF SPECIMEN

The proportioning of materials used in concrete mixtures for determining their suitability were the same in all respects. Where the proportions are specified by volume, they are calculated by weight and unit weight. The mix proportions for M20 (1:1.5:3) were calculated as per IS: 10262-2009.

A total number of 90 cubes of size 100mmx 100mmx100mm, 15 cylinders of size 150mm diameter, 300mm height and are designated as 0G, 2.5G, 5.0G and 7.5G for the concrete with 0.40 w/c ratio. In all the designations 0, 2.5, 5.0, and 7.5 indicates the % of ground granulated blast slag (ggbs) with constant addition of 2.5% banana fibre by volume of concrete reinforced in the concrete.

EXPERIMENTAL INVESTIGATION

The various tests that were performed on the test samples were: Workability Test, StrengthTest, Bulk Density, Water Absorption, Apparent Porosity, Rebound Hammer, Ultrasonic Pulse Velocity (UPV). The results of the tests are reported as average of three specimens. The details of specimens are given in Table 1. NPC & C0 is the normal plain concrete specimen. G represents GGBS reinforced concrete specimen with constant replacement of 2.5% banana fibre at different pecentages of ggbs.

Table-1: Details of Test Specimen

Specimen ID	% of GGBS	% of Banana fibre
C0	0	0
G1	0	2.5
G2	2.5	2.5
G3	5	2.5
G4	7.5	2.5

RESULTS AND DISCUSSIONS

Slump Test

Slump test is performed to check the consistency of freshly made concrete before it sets. The test results

are presented in Table-2 and the results shows that the workability of concrete mix increases with the increase in GGBS replacement percentage while keeping the reinforcement of fibre constant at 2.5%.

Table-2: Slump Test of Specimen

Specimens	% of GGBS	Slump value (mm)
C0	0	0
G1	0	0
G2	2.5	1.2
G3	5	2
G4	7.5	2.8

Compaction Factor Test

The compacting factor test is used to carry out the degree of workability of freshly made concrete. This test gives better results than that of the slump test but it is less common. The test results are presented in Table-3. Due the presence of banana fibre, compacting factor value tends to be low, hence the degree of workability is low.

Table-3: Compaction Factor of Specimen

Specimens	% of GGBS	Compaction factor value	Quality
C0	0	0.734	Very low
G1	0	0.771	Very low
G2	2.5	0.846	Very low
G3	5	0.873	Very low
G4	7.5	0.891	Very low

Compressive Strength

Compressive strength of specimen after 7 days curing is determined and are presented in Table-4 and Figure 1.

Table-4: Compressive Strength of Specimen

Specimens	Percentage of GGBS replacement	Compressive strength (N/mm²)
C0	0	30.11
G1	0	32.00
G2	2.5	36.40
G3	5	35.18
G4	7.5	32.18

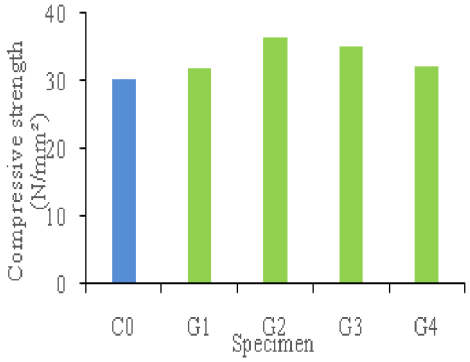

Figure 1 : Compressive Strength of Specimen

The results shows that the optimum compressive strength of 36.4 MPa is obtained for G2 specimen with 2.5% of both ggbs and banana fibre. Addition of banana fibre along with replacement by GGBS is found to improve compressive strength

Table-5: Split Tensile Strength of Specimen

Specimens	Percentage of GGBS replacement (%)	Tensile strength (N/mm²)
C0	0	5.13
G1	0	6.26
G2	2.5	9.37
G3	5	7.25
G4	7.5	6.29

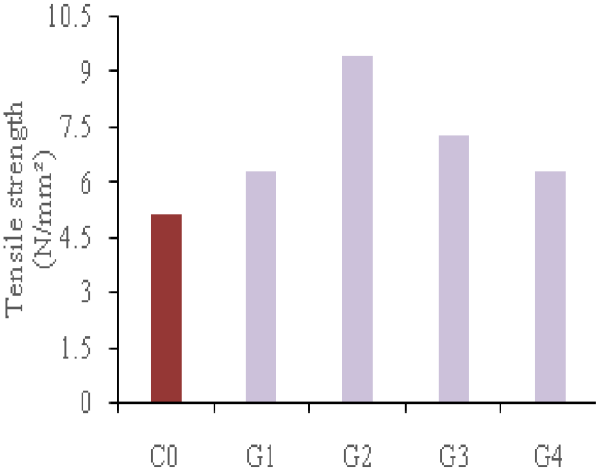

Figure 2 : Split Tensile Strength of Specimen

From the result, it is found that the tensile strength of concrete was found to be optimum at 2.5% for both the banana fibre and GGBS replacement. Moreover, the concrete mix with added GGBS and banana fibre obtains better tensile strength than normal plain concrete.

Bulk Density

Bulk density of the banana fibre reinforced GGBS concrete at different percentages are shown in Table VI and Figure 3.

Table-6: Bulk Density of Specimen

Specimens	Percentage of GGBS replacement (%)	Density (g/mm³)
C0	0	1925.93
G1	0	1925.01
G2	2.5	2000.03
G3	5	2010.19
G4	7.5	2010.81

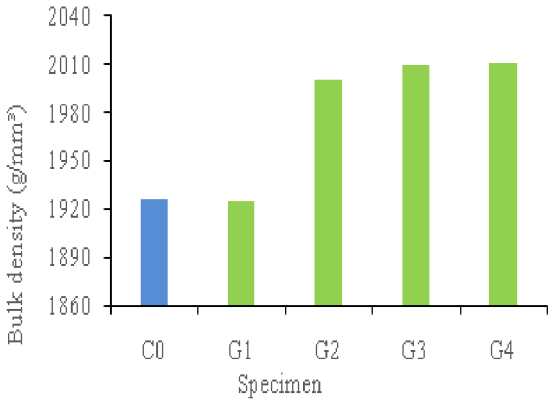

Figure 3 : Bulk density of specimen

Bulk density was found to increase with increasing addition of GGBS. However, there is rapid increase in bulk density from G1 having no GGBS to other specimens incorporated with GGBS.

Water Absorption

The results of the water absorption of specimen are as shown in Table-7 and Figure 4.

Table-7: Water Absorption Of Specimen

Specimens	Percentage of GGBS replacement (%)	Water - Absorption
C0	0	8.21
G1	0	7.80
G2	2.5	7.50
G3	5	7.77
G4	7.5	7.79

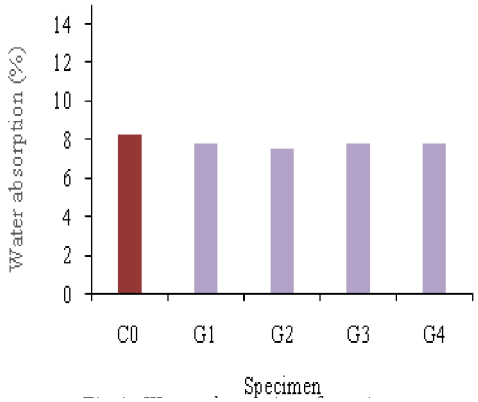

Figure 4 : Water Absoprtion of Specimen

The results showed that specimen G2 prepared with 2.5% GGBS performed best among the specimens in terms of water absorption. It resulted in lower water absorption as compared to normal plain concrete.

Apparent Porosity

The value of apparent porosity obtained are shown in the Table-8 and Figure 5.

Table-8: Apparent Porosity of Specimen

Specimens	Percentage of GGBS replacement (%)	Apparent Porosity
C0	0	15.30
G1	0	16.07
G2	2.5	15.91
G3	5	15.75
G4	7.5	15.50

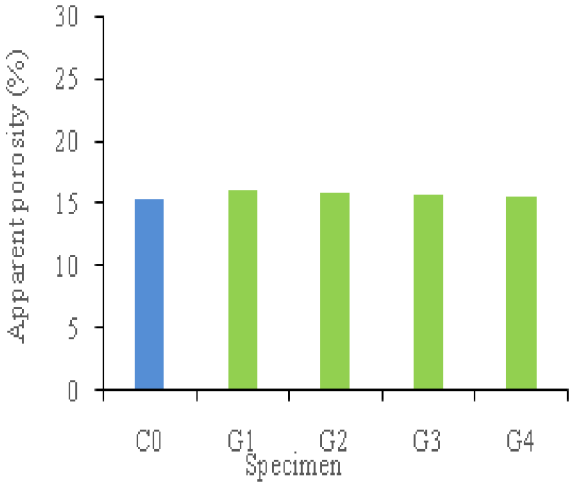

Figure 5: Apparent Porosity of Specimen

The apparent porosity was found to decrease with the increase in percentage of GGBS in the specimens. The results could be related to the water absorption.

However, no significant decrease was observed among the specimens.

Rebound Hammer Test

The rebound hammer test distinguishes three modes of operation. They are impact mode, set-up mode and review mode. This is the test performed to determine the hardness of the concrete surface. The rebound number and the corresponding compressive strength of the cubes are as shown in Table-9 and Figure 6.

Table-9: Rebound Hammer Strength of Specimen

Specimens	Percentage of ggbs replacement	Rebound Number (N)	Compressive strength (N/mm²)
C0	0	42	52.67
G1	0	30	30.67
G2	2.5	42	49.00
G3	5	45	54.67
G4	7.5	46	55.33

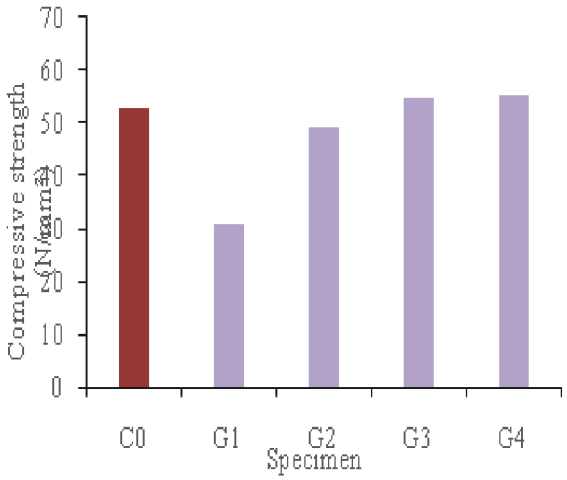

Figure 6 : Rebound hammer of specimen

The results of rebound hammer test clarifies that the strength is directly proportional to the percentage ofalong with 2.5% banana fiber throughout the rebound hammer test. The least compressive strength was obtained at G1 where the concrete mix contains of 2.5% of banana fibre.

Ultra-sonic Pulse Velocity Test

Higher speeds indicate better material quality and integrity, while lower speeds can indicate concrete with many cracks or voids. The results that are obtained for specimen are as shown in Table-10.

Table-10: Ultra-Sonic Pulse Velocity of Specimen

Specimens	% of GGBS	Time	Pulse Velocity	Quality
C0	0	13.2	3693	Good
G1	0	16.1	3114	Medium
G2	2.5	16.2	3081	Medium
G3	5	14.7	3416	Medium
G4	7.5	13.5	3704	Good

UPV test results indicate medium quality grading for most of the specimens replaced with GGBS, though G4 specimen which had maximum replacement level at 7.5% GGBS showed good quality of concrete.

CONCLUSION

Making concrete with the combination of GGBS and banana fibre as a partial replacement of cement and natural sand with different percentages gives good results compared to normal plain concrete.Therefore, a satisfactory way to use these materials is to combine them. In terms of value, the market price of GGBS, including packaging and transportation, is 3 times lower than that of OPC. While banana fiber is one of the agricultural waste, hence this fiber can be used for good purposes in concrete. Thus, it can be concluded that mixing concrete with GGBS for cement and natural sand with banana fiber would be an economical and environmentally friendly option..

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