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Experimental Investigation on Groundnut Shell Ash(GSA) and Bamboo Fiber as Partial-replacement of Cement

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ABSTRACT

Groundnut shell ash(GSA) and Bamboo fiber as sustainable additives in concrete. Groundnut shell ash, a byproduct of agricultural waste is Abundant and cost effective ,while bamboo fiber are known for there High strength and durability. The concrete mixture were prepared with varying proportions of groundnut shell ash and bamboo fiber and test for Compressive strength, Flexural strength, Split tensile Strength. The result show that the addition of Groundnut shell ash and Bamboo fiber improved the Mechanical properties of the concrete. The composite also Exhibited enhanced resistance to cracking and Improve durability.Therefore the Groundnut shell ash partial replacement of Cement in concrete. The density ,Slump and compressive strength of concrete are tested the replacement of Cement by Groundnut shell ash by 0%, 5%, 10% and 15% proportions. The Bamboo fiber as partial replacement of cement in concrete. The density, Slump and compressive strength of concrete are tested the replacement of cement by bamboo fiber by 0%, 0.5%, 1% and 1.5% proportions.

Keywords: Groundnut Shell Ash, Bamboo Fiber, Cement, Concrete, Compressive Strength, Flexural Strength, Split tensile Strength.

1. INTRODUCTION

In the quest for sustainable construction practices, researchers are continuously exploring novel materials and techniques to reduce the environmental footprint of the built environment. One such avenue is the development of concrete formulations that utilize locally available, renewable, and waste-derived materials. This approach not only addresses the growing concerns of resource depletion and pollution but also promotes resilience against supply chain disruptions by relying on readily accessible resources.

The integration of bamboo fiber and groundnut shell ash into concrete mixes represents a paradigm shift towards more sustainable building materials. Bamboo, with its rapid growth and high tensile strength, offers a renewable alternative to traditional reinforcement materials like steel. Similarly, groundnut shell ash, a byproduct of agricultural processing, not only diverts waste from landfills but also adds beneficial properties to concrete, such as improved workability and durability.

Moreover, by incorporating additives like Ceraplast 300, which is derived from recycled materials, into concrete formulations, the industry can further enhance the performance and sustainability of construction materials. This holistic approach to material selection and formulation embodies the principles of circularity, where resources are utilized efficiently and waste is minimized throughout the product lifecycle.

In addition to environmental benefits, sustainable concrete mixes offer economic advantages by reducing material costs and enhancing long-term durability. By extending the service life of concrete structures and minimizing maintenance requirements, these materials contribute to overall life-cycle cost savings for infrastructure projects.

Furthermore, the adoption of sustainable construction practices is increasingly driven by regulatory requirements and market demand for environmentally responsible solutions. As governments around the world

implement stricter building codes and green building standards, the demand for eco-friendly construction materials is expected to grow, creating new opportunities for innovation and investment in the construction sector.

In this study, the integration of bamboo fiber, groundnut shell ash, and other renewable materials into concrete mixes represents a significant step towards achieving a more sustainable and resilient built environment. By embracing these alternative materials and practices, the construction industry can reduce its environmental impact, enhance economic viability, and contribute to a more sustainable future for generations to come.

2. MATERIALS AND METHODS

2.1 Materials

2.1.1 Cement

Ordinary Portland Cement (OPC)

OPC 53 Grade used for this study as per IS:8110-2013 for binding material. It was obtained from the open market at Tamilnadu state, India. The quality of cement was considered by testing setting time, consistency and strength. These tests were carried out on the qualities of the cement with 5%, 10% and 15% replaced of the cement with groundnut shell ash.

2.1.2 FINE AGGREGATE

M-Sand

In this research, The M-Sand is used as Fine Aggregate. It was used sieved through less than a IS 4.75mm sieve as per IS 2386:1963.It is a granular materials composed of finely divided rock and mineral particles. The sand free from clay, silt and organic impurities. The coefficient of Absorption of the Fine Aggregate used was 1% and Fineness value which indicates that it good for concrete.

2.1.3 COARSE AGGREGATE

Coarse Aggregate is the crushed gravel or stone, uncrushed gravel or stone or partially crushed gravel stone.Crushed granite gravel having the minimum size of 16mm and maximum size of 20mm was chosen as the coarse aggregate. According with BS: 812-1970 and aggregate is taken as per the IS: 383-1970.

2.1.4 WATER

The Water used in the study was clean and clear. It was free from bacteria and other impurities. There was no acid content in it. The water is used for the mixing and curing of content should be free from deleterious materials. The water cement ratio for the concrete mix is 0.5. As per using IS:456-2000.

2.1.5 GROUNDNUT SHELL ASH (GSA)

Groundnut shell ash was used as secondary cementitious materials.It is a by product of groundnut processing Industry. It is obtained from burning of groundnut shell by using manually under normal temperature. After burning, ash will generate. More over it was sieved by the 90 microns.

2.1.6 BAMBOO FIBER (BF)

Bamboo fiber is the naturals fiber it is extracted from Bamboo Tree. It is one of the Fast-growing naturals reserves. It has been used since ancient times. It gives high strength to Tensile and Flexural, more over it improve the sound insulation of concrete. The bamboo fiber used had a maximum length of 10mm with varying diameter specific gravity test is carried out. In this research, the percentage of bamboo Fiber was utilized from the range of 0.5%, 1%, and 1.5% for improve the strength of concrete.

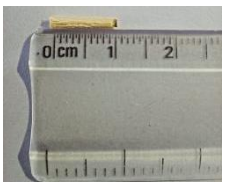
2.1.7 SUPER-PLASTICIZER

The used of super plasticizer in this study is cera-plast 300. It improve the early strength and durability and reduce the water cement ratio. The recommended uses of superplasticizer in concrete is 500 to 550ml of 50kg of cement.

2.2 MATERIAL TEST

S.NO	MATERIALS	PROPERTIES	RESULT
1.	Cement	Specific gravity Initial setting time(min) Final setting time(min)	3.14 35 628
2.	Fine aggregate	Specific gravity Fineness modulus Water absorption(%) Bulk density(Loose)[Kg/lit] Bulk density(Tamp)[Kg/lit]	2.5 3.90 1.0 1.503 1.705
3.	Coarse aggregate	Specific gravity Fineness modulus Water absorption(%) Impact test(%) Bulk density(Loose)[Kg/lit] Bulk density(Tamp)[Kg/lit]	2.7 6.02 1.7 12.8 1.208 1.436
4.	Groundnut shell ash	Specific gravity	2.65
5.	Bamboo fiber	Specific gravity	0.7
6.	water	Specific gravity	1

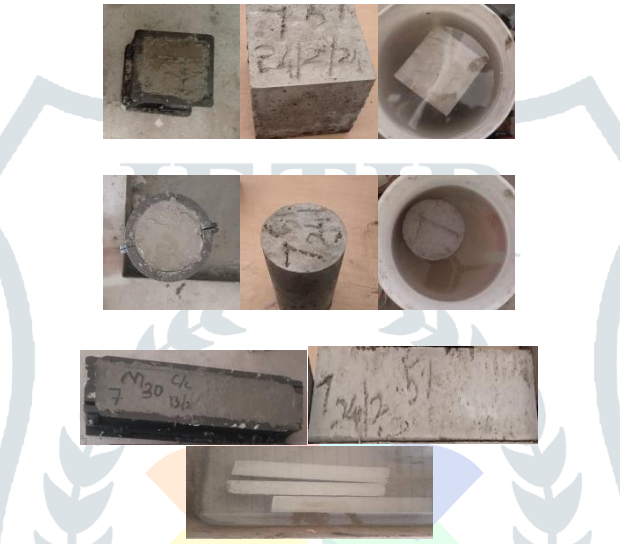
Groundnut Shell Ash



Bamboo fiber

2.3 METHODS

The concrete mix ratio of 1:2.87:3.23 with a water-cement ratio of 0.5 was used for producing concrete cubes. Cement content was replaced at 5%, 10%, and 15% with groundnut shell ash, while bamboo fiber was added at 0.5%, 1%, and 1.5% to enhance concrete strength, based on the research of Bhari T.A, Ademola S.A, and Ayegbokiki S.T. Cube specimens measuring 150mm x 150mm x 150mm for compressive strength, cylinder specimens of size 150mm diameter x 300 mm height for split tensile strength, and prism size of 100mm x 100mm x 500mm for Flexural strength were cast according to Indian standards. The moulds were tightly fitted, and their inner sides were thoroughly oiled before concreting. The concrete was then placed in the moulds and compacted using a vibration table. After compaction, the top surfaces were leveled with a trowel. The specimens were stripped from the moulds after 24 hours and cured in a water tank for 7, 14, and 28 days. The average of three specimens was crushed for each test, and the results are shown in the analysis.



Casting → Demould → Curing → Test

2.3.1 SLUMP CONE TEST

The slump test was conducted in the lab to analyze the work-ability of concrete mixes with varying percentage of groundnut shell ash and bamboo fiber. The main objective was to determine the water-cement ratio considering factors such as materials,mixing method and Admixture. The test aimed to assess the uniform quality of concrete mixes.The slump values for different percentages of partial replacement of cement with groundnut shell ash and bamboo fiber are summarized in the table below

2.3.2 COMPACTION FACTOR TEST

The compaction factor test procedure evaluates the work-ability of concrete mixes containing groundnut shell ash and bamboo fiber as partial replacements for cement at 5%, 10%, and 15%. This test assesses the ease of compacting and molding the concrete mix. Prepare the mixes by substituting the specified percentages of cement with groundnut shell ash and bamboo fiber. Conduct the test by filling a standard compaction cone with the mix in layers, compacting each layer uniformly with a tamping rod. Measure the height before and after compaction to determine the compaction factor. A higher factor indicates better work-ability, implying easier placement and molding. Analyze the results to determine the optimal percentage of groundnut shell ash and bamboo fiber for achieving the desired work-ability while maintaining structural integrity.

2.3.3 COMPRESSIVE STRENGTH TEST

The Compressive strength test was conducted to assess the strength of concrete cubes at different ages (7 days,14 days and 28 days). The cubes were removed from the water tank and exposed to direct sunlight for precisely 30 minutes.After wiping off any moisture,The cubes were tested using a Compressive testing machine . The test aimed to determine the load at which cracks formed on the cubes . cube dimensions were 150x150x150mm.

2.3.4 SPLIT TENSILE STRENGTH TEST

The split tensile strength test assesses the strength of concrete containing groundnut shell ash and bamboo fiber as partial substitutes for cement at 5%, 10%, and 15% increments, conducted at both 14 and 28 days. Using molds measuring 150*300, prepare cylindrical specimens from the concrete mixes. After curing for the specified durations, subject the specimens to splitting tensile forces using a testing machine. Measure the maximum tensile load applied and calculate the split tensile strength. Analyze the results to determine the effects of varying percentages of groundnut shell ash and bamboo fiber on the concrete's tensile strength over time.

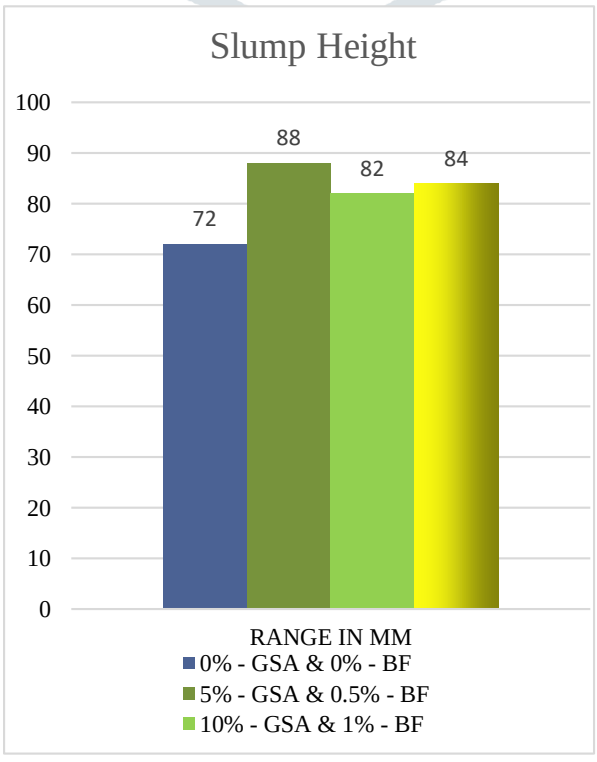
2.3.5 FLEXURAL STRENGTH TEST

The performance of concrete containing groundnut shell ash and bamboo fiber in a Flexural strength test is evaluated by applying a load to a prism of the concrete sample and measuring its deflection and corresponding stress. This test assess the materials ability to withstand bending or flexing forces, determining its Flexural strength, modulus of rupture and other mechanical properties. The ratio tested include 5%,10% and 15% groundnut shell ash as partial replacement for cement, using a prism mould size of 100x100x500mm.

2.4 TABLES AND RESULT

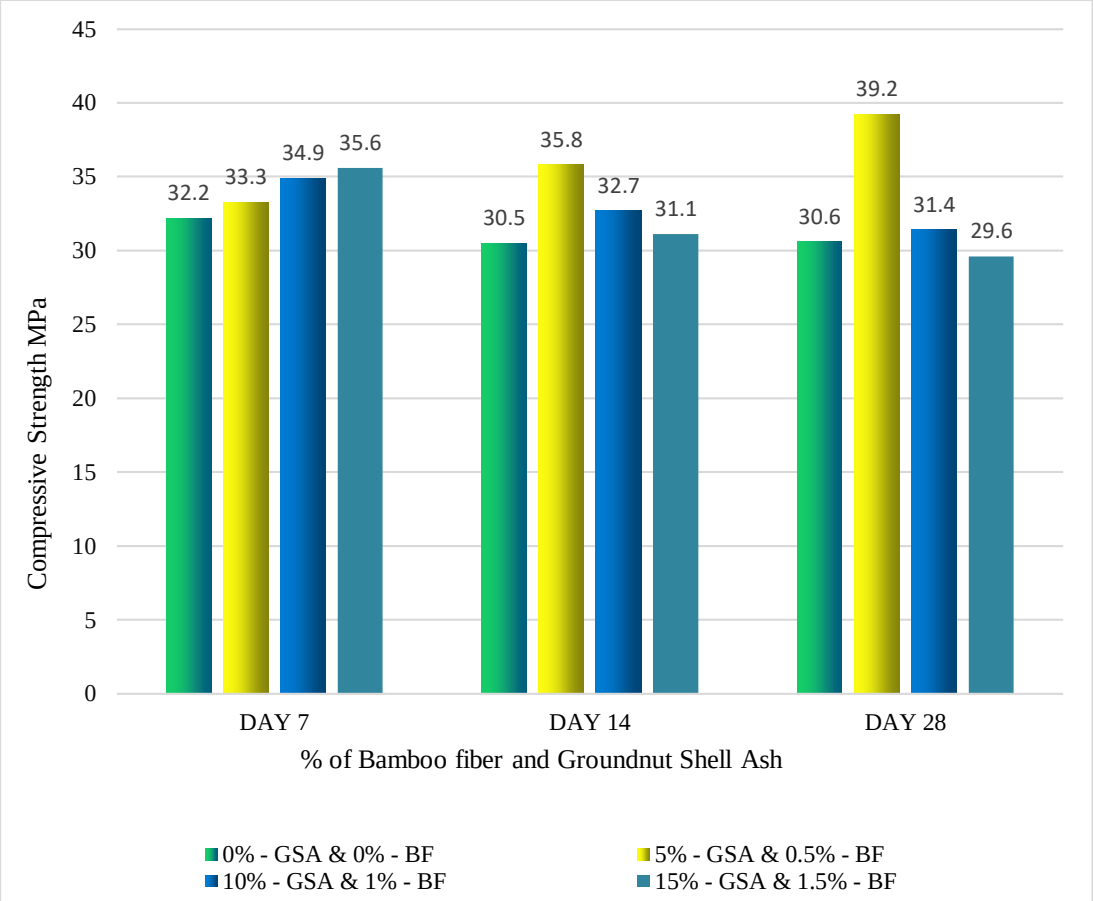
2.4.1 SLUMP CONE TEST RESULT

Mix ID	Slump Height (mm)
0% GSA & 0% BF	72
5% GSA & 0.5% BF	88
10% GSA & 1% BF	82
15% GSA & 1.5% BF	84



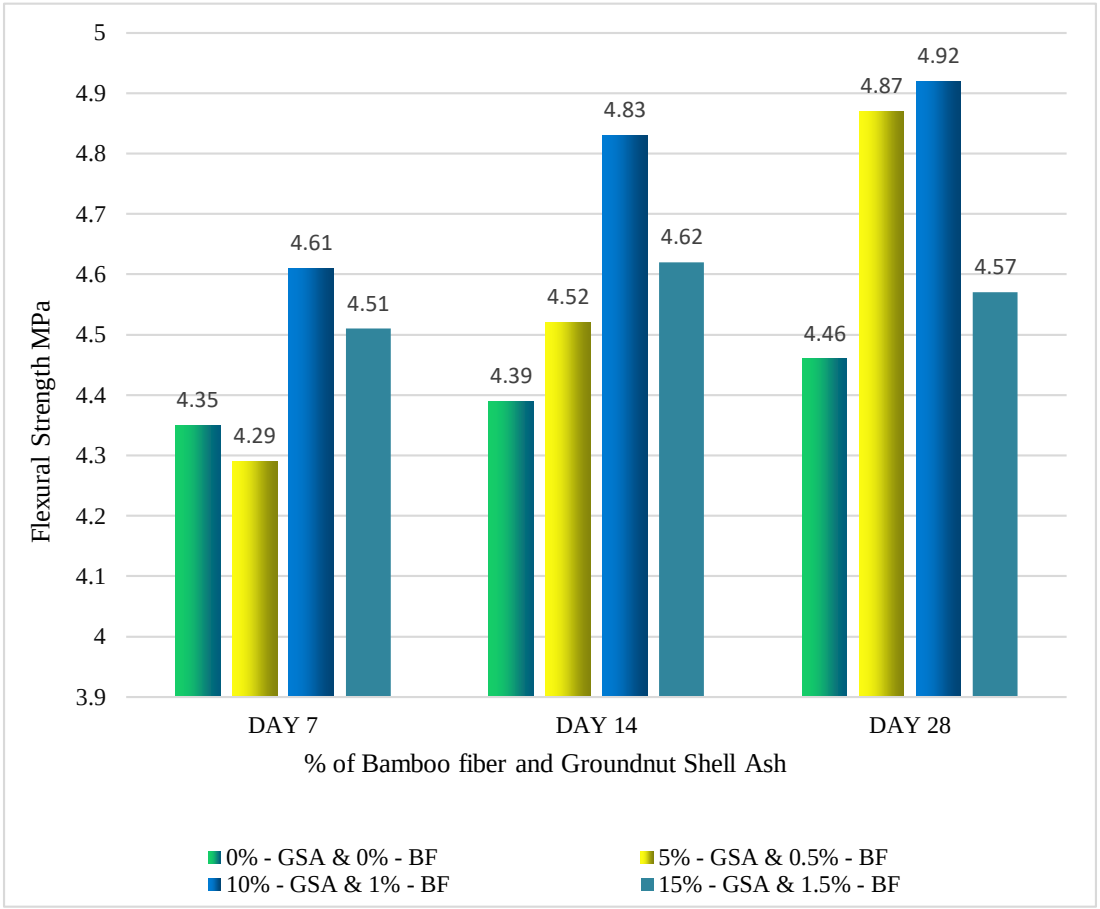
2.4.2 COMPRESSIVE STRENGTH TEST RESULT

Mix ID	0%GSA& 0%BF (MPa)	5%GSA& 0.5%BF (MPa)	10%GSA& 1%BF (MPa)	15%GSA& 1.5%BF (MPa)
7 days	32.2	33.3	34.9	35.6
14 days	30.5	35.8	32.7	31.1
28 days	30.6	39.2	31.4	29.6



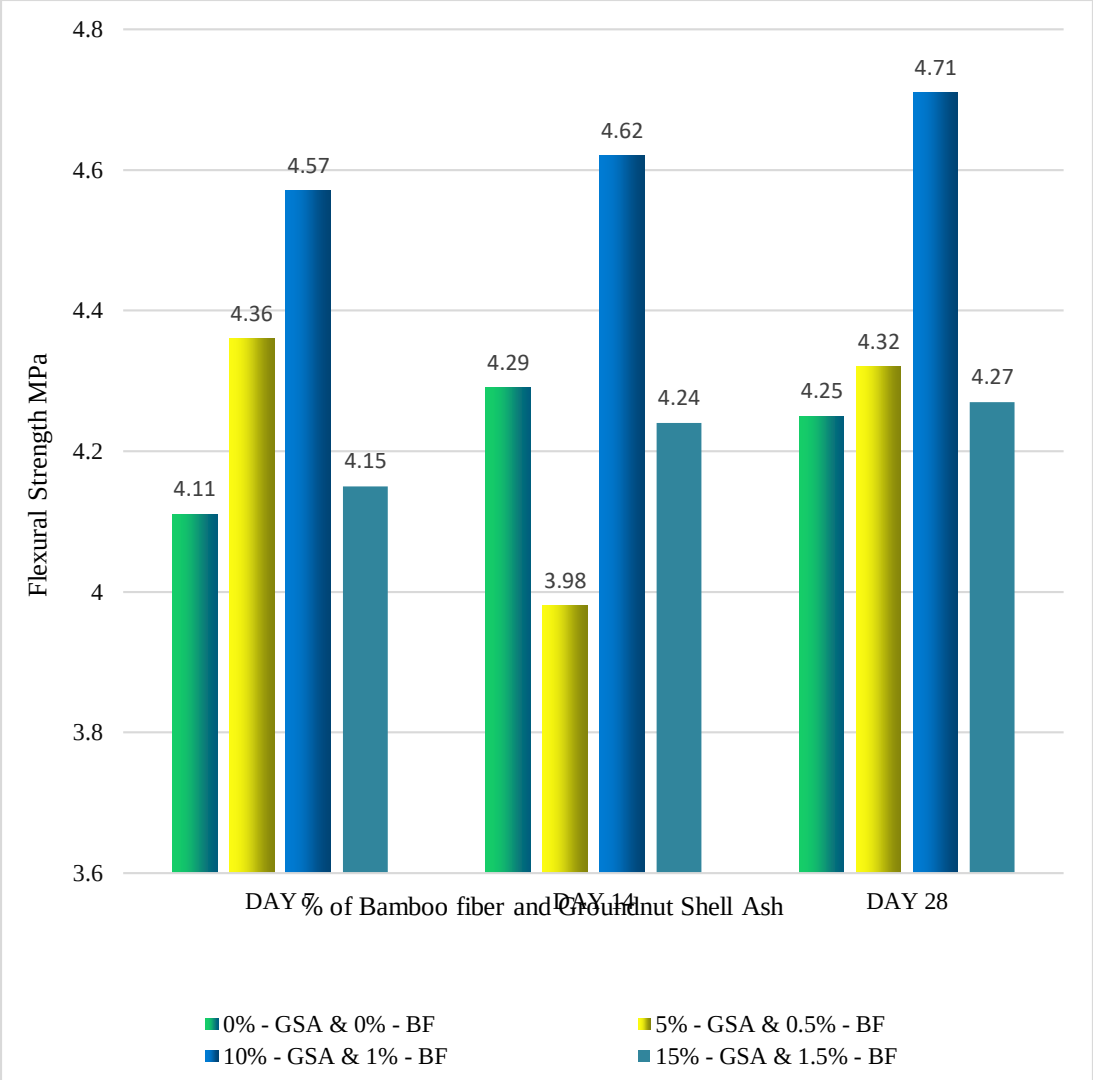
2.4.3 FLEXURAL STRENGTH TEST RESULT

Mix ID	0%GSA & 0% BF (MPa)	5%GSA & 0.5% BF (MPa)	10%GSA & 1% BF (MPa)	15%GSA & 1.5% BF (MPa)
7 days	4.35	4.29	4.61	4.51
14 days	4.39	4.52	4.83	4.62
28 days	4.46	4.87	4.92	4.57



2.4.4 SPLIT TENSILE STRENGTH TEST RESULT

Mix ID	0%GSA & 0% BF (MPa)	5%GSA & 0.5% BF (MPa)	10%GSA & 1% BF (MPa)	15%GSA & 1.5% BF (MPa)
7 days	4.11	4.36	4.57	4.15
14 days	4.29	3.98	4.62	4.24
28 days	4.25	4.32	4.71	4.27



3. CONCLUSION

The experiment demonstrated that incorporating groundnut shell ash as a partial cement substitute alongside bamboo fiber in concrete formulations can significantly enhance its mechanical properties. The findings indicate that substituting 5% of cement with groundnut shell ash and adding 0.5% bamboo fiber maintains satisfactory compressive strength, crucial for load-bearing structures. Improved tensile and Flexural strength, a 10% cement replacement with groundnut shell ash, combined with 1% bamboo fiber, offers optimal results. Based on the above observation, the 10% to GSA as partial replacement of cement and 1% of bamboo fiber is recommend of construction industry.

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