



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 5, May 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118

9940 572 462

6381 907 438

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An Experimental Study to Evaluate the Performance of Straw and Banana Fiber as a Material Combination in Concrete Blocks

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ABSTRACT: Concrete is considered one of the most adaptable and commonly utilized building materials on the planet as it possesses numerous advantages over stone, bricks, and steel, etc. Though it is such a crucial component it is not environment friendly. The building industry is a major sector that depends on concrete, so any changes here can have global effects. The study aims to reduce the consumption of resources by assessing the influence of recycling rice straw ash as cement replacement material and banana fibers as a reinforcement ingredient in concrete. Three mix proportions with ash-to-fiber ratio as 10:2, 15:4, 20:6 were made into concrete blocks of size 4x8x12 inches and cured for a period of 28 days. A series of compression tests and water absorption test were carried out at 7- & 28-day intervals and results were compared with normal block and a new formwork. It was observed that the strength of the new mix is low compared to the normal block and as the percentage of addition increases at the rate of 5:2, the strength of concrete decreases and at the same time water absorption by the block increases. The deficiency in strength can be solved by alterations in the form of the block to withstand more pressure.

KEYWORDS: Partial replacement, Rice straw ash, Banana fiber reinforcement, Compressive strength, Water absorption

I. INTRODUCTION

Concrete is widely used as a building material due to its versatility and numerous advantages over stone, bricks, and steel. It is made up of portland cement, fine and coarse aggregates, water, and additives. The demand for cement continues to rise as the use of concrete grows. However, cement production is harmful to the environment because it generates heat and releases carbon dioxide emissions. The high consumption of resources is also a cause for concern. Given that the construction industry heavily relies on concrete, any changes in this sector can have global implications. Therefore, the study aims to reduce resource consumption by exploring the impact of using recycled rice straw ash (RSA) as a replacement for cement and banana fibers (BF) as a reinforcing component in concrete.

1.1 Aim and Objectives

The aim is to evaluate the performance of a concrete block created by the partial replacement of cement by rice straw ash and banana fiber as a reinforcement component. It is to understand how practical the block is compared to an ordinary block and to suggest methods to enhance strength if found lacking. The objectives of the study are;

- To determine the compressive strength of such a concrete block
- To compare the newly developed block with the standard one to assess the effect of replacement
- To explore the practical aspects of the new block
- To suggest methods for improvement if necessary

Inferences are taken only after proper tests have been carried out. The scope of the study is to provide a more green building material to the building industry. The study has a few limitations; equipment shortage, time shortage, lack of processed raw materials within the study timeframe.

II. MATERIALS

2.1 Concrete.

It is the world's most widely used construction material after water, and for good reason. It is a strong, durable, and

versatile material that has a wide range of applications. concrete is a mixture of water, cement and aggregates (like sand and gravel) that hardens over time to create a solid, strong substance. It's used in all sorts of construction projects because it's affordable, durable, and can be molded into nearly any shape. M10 is the most commonly used mix for making concrete blocks. Understanding the elements used for making concrete is the basic step for the study.

2.2 Cement.

It is a chemical substance used in construction to bind materials together. It sets, hardens, and adheres to other materials. Ordinary portland cement with initial and final setting times of 30 minutes and 600 minutes was found ideal for the project.

2.3 Aggregates.

In a good concrete mix, aggregates should be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could lead to concrete deterioration. Aggregates are categorized as "coarse" or "fine." Coarse aggregates are particulates greater than 4.75mm in diameter, usually ranging from 9.5mm to 37.5mm. On the other hand, fine aggregates are typically sand or crushed stone less than 9.55mm in diameter.

2.4 Banana fiber.

They are readily available worldwide as a by-product of banana farming. These environmentally friendly fibers offer significant advantages, including low density, lightweight, low cost, water and fire resistance, and excellent tensile strength. Composed of cellulose microfibrils embedded in an amorphous matrix of hemicelluloses and lignin, BF's mechanical characteristics are influenced by both the cellulose content and the microfibril angle of the fibers. Alkali treatment increases surface roughness, leading to better mechanical bonding and an increase in the amount of exposed cellulose on the fiber surface, thereby providing a greater number of potential reaction sites and allowing for better fiber wetting. Chemical treatment with NaOH proportion of 3% increases the compressive strength of the fiber up to 10-15% and removes the moisture content of the fiber¹. Also the varying length of fiber and its percentage should also be considered for its tensile strength. For optimal purposes, addition of banana fibers should be limited to a maximum of 1% fiber content preferably using shorter fibers instead of longer ones².

2.5 Rice straw ash. Produced in significant quantities globally. Although they are used in some regions, in others they are considered waste, causing pollution and disposal issues. When burned, rice straw ash is highly pozzolanic and suitable for use in lime-pozzolana mixes and as a replacement for Portland cement. Studies conducted on wheat straw ash as Cementous replacement suggest that, The maximum compressive strength was determined at 10% replacement level, whereas minimum compressive strength was observed at 20% replacement³.

III. METHODOLOGY

Qualitative analysis should be carried out to evaluate the performance of the new material. This involves experimenting with different combinations and testing out the resulting samples. For suggesting improvements, sufficient test data should be there to consider it as an improvement such as compressive strength test.

3.1 Procedure

To assess the strength of the mix we must conduct a compressive test and to assess the absorption factor, a water absorption test should also be conducted. Based on the literature study the opted mix proportions are 10% RSA: 2% BF, 15% RSA: 4% BF and 20% RSA: 6% BF. The step-by-step process of how it is done is as follows:

1. Procuring materials required such as fine aggregate, coarse aggregate, cement comes first
2. Procure rice straw and burn it in order to obtain ash. Let the ash cool and collect it
3. Procure banana fibers, dry them and treat them in 3 % NaOH solution for 2 hours and dry it. After which the fibers can be cut to 40mm size
4. Using the materials prepare the first mix that is a mix of 1:3:6 (cement : fine aggregate : coarse aggregate) with 10% RSA replacing cement and 2% BF
5. Use the mix to make 3 blocks, one for compression test at 7 days, one for compression test at 28 days and one for water absorption test.
6. Repeat the same process for 15% RSA: 4% BF mix and 20% RSA: 6% BF mix
7. Ensure that the block is in the right shape
8. Cure it for 28 days



Figure 1: Treatment of banana fiber with 3% NaOH solution



Figure 2: mechanical mixing

3.2 Tests

First comes compression test, this test must be performed at 7 and 28 day intervals:

1. Check the sample dimensions
2. Use a compression testing machine (UTM) to find out the load
3. Record the value and repeat the process for the other samples
4. Tabulate the values in a table
5. Find compressive strength by dividing load in newton with the area of the surface on to which compression was applied

Now for Water absorption test:

1. Measure the dry weight of the samples before the test
2. Immerse the block completely in water for 24 hours
3. Measure the weight again
4. Water absorption can be calculated by reducing the initial weight from the final weight and then dividing it by initial weight
5. Record the values in the table.



Figure 3: Compression test



Figure 4: Water absorption test

3.3 Testing out improvement option

A mold is prepared according to the design using iron and is cleaned for the casting process which is as follows:

1. Clean the mold and dry it using a cloth
2. Use oil on the surface of the mold before casting for easy removal
3. Add the mix bit by bit and compress it, use a stick to vibrate the mold to let out air bubbles and ensure an even distribution.
4. Use wet cloth and plastic to cover the mold and let it dry for 24 hours
5. Remove the mould
6. Perform compressive strength test on 7 and 28 day intervals
7. Compare the results with a normal block

Analyze these data



Figure 5: New form exploration

IV. DATA ANALYSIS AND FINDINGS

Collect the data from the test that is the result of the compressive test on 5 samples and record them in tables for calculation. Perform similar steps for the water absorption test.

Table 1: Result of compression test

SAMPLE NAME	DIMENSION	LOAD AT 7 DAYS (KN)	LOAD AT 28 DAYS (KN)	COMPRESSIVE STRENGTH AT 7 DAYS (N/mm ²)	COMPRESSIVE STRENGTH AT 28 DAYS (N/mm ²)
Normalblock	150x300x200mm	175	260	3.9	5.7
Sample 1	100x300x200mm	110	160	3.6	5.3
Sample 2	100x300x200mm	50	150	3.2	5
Sample 3	100x300x200mm	95	120	3.16	4
Customblock	100X200X100mm	65	-	3.4	-

Table 2: Result of water absorption test

SAMPLE NAME	INITIAL WEIGHT(KG)	FINAL WEIGHT(KG)	PERCENTAGE OF WATER ABSORPTION
SAMPLE 1	11	12	9
SAMPLE 2	12	13.2	10
SAMPLE 3	12.8	14.3	11.7

V. RESULTS AND DISCUSSION

Plot the collected data in graphs and analyze the behaviour of the new material. It is observed that there is a loss of strength as the concentration of addition increases on the other hand as concentration of addition increases water absorption also increases. It is also observed that the new form is stronger than normal one for the same mix

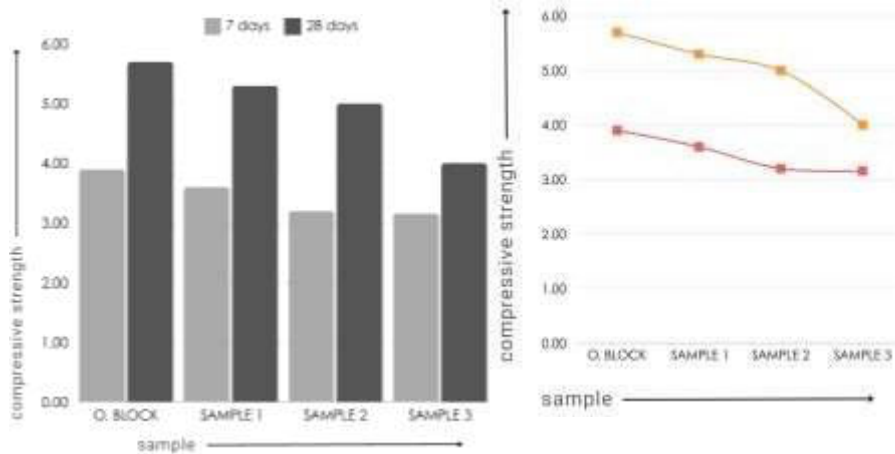


Figure 6: graphical representation of result of compression

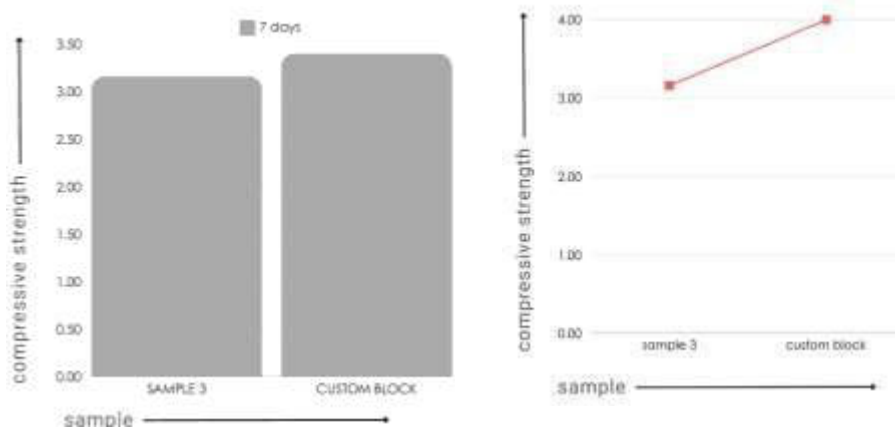


Figure 7: graphical representation of the result of compression test of improved design

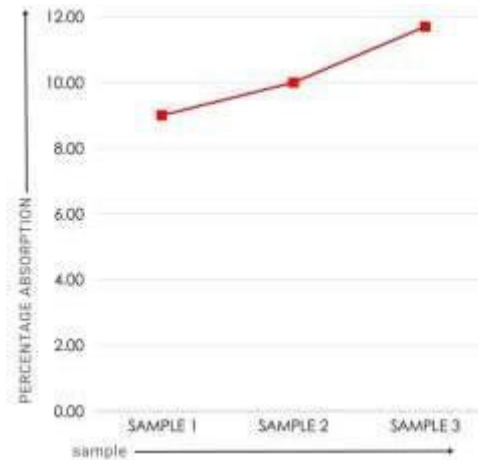


Figure 8: graphical representation of the result of water absorption test

The usage rice straw ash and banana fiber did cause a decrease in strength as addition increased but the first sample with 10% rice straw ash and 2% banana fiber showed desirable strength. This indicates even though it won't result in increased strength, rice straw ash reinforced with banana fiber can function as a partial replacement for cement. Form-based alteration like the one performed can result in increased strength but it is not recommended for heavy loads. It can function effectively in partition walls and light weight structures. 10% RSA and 2% BF is the optimal mix according to this study. This mix can reduce cement conception by 10% thus it is step towards a more greener approach.

VI. CONCLUSIONS AND RECOMMENDATIONS

While assessing the performance of rice straw ash and banana fiber as a material combination in concrete blocks, it is observed that as the concentration of ash and fiber increases at the rate of 5:2, the strength of block decreases. and when compared to a normal block the new mixes were weaker. The first mix which is 10% rice straw ash and 2% banana fiber showed maximum strength compared to other mixes but when compared to a normal block the new mixes were weaker. It was also observed that as the concentration of fiber and ash increases at the rate of 5:2 water absorption also increases. The strength deficiency can be solved by alteration in block form, which will help it to withstand more pressure, in the experiment that followed there was an increase in strength by 7.6% and a reduction in material usage just by form alteration. A more stable mix can be formulated using the method of design of experiments furthermore research on form alterations may lead to a more stable block with this proportion.

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