"Fabrication and Characterization of false banana fiber reinforced gypsum composite"

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Abstract:

The increase in environmental awareness, pollution and lack of resources has resulted in great research interest of materials that are friendly to our health and environment. Composite materials can be used for a variety of applications. For instance, polymeric composites have high strength and stiffness, light weight, low cost, low density, high toughness, and high corrosion resistance. This research paper focuses on Fabrication and Characterization of Chopped Short False Banana Fiber Reinforced Gypsum Composite. Experimental investigation has been carried out to find out the effect of false banana fiber at different weight percentages of 5, 20, 30 and 40 to modify gypsum resin mechanical properties. 100 KN servo hydraulic universal testing machine was used to test specimen. An effort has done to manufacture the composite material using gypsum resin and false banana fiber to improve mechanical and physical properties—and this was the main focus of this paper. The research finding shows that 20 wt.% of false banana fiber mixed gypsum gave optimum properties and was found to be better than other weight percentages composites. The properties of the new false banana fiber composite was compared with glass fiber reinforced epoxy composite manufactured using hand lay-up techniques. The addition of false banana fiber has improved tensile, flexural and impact properties of gypsum resin, increasing water absorption of the material. According to the results, false banana fiber can be a potential candidate for use in natural fiber reinforced composite and is intended to improve its mechanical and physical properties. When compared to glass fiber reinforced epoxy resins composite, it has less mechanical properties. These composites can find application in interior decoration as false ceiling and wall partitioning for domestic and industrial purpose as construction materials.

Key words: False banana fiber, Gypsum, Mechanical properties, Water absorption, hand lay-up Technique

1 Introduction

Currently, worldwide environmental and economic interests motivate researchers in designing new materials whose significant portion is based on natural renewable resources in order to avoid further pressure on the environment without compromising in terms of cost and performance.

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A composite is a material prepared by combining two or more different material in such a way that the resultant material advanced with optimum properties to any of its parental ones. They are the most promising materials nowadays.
These materials can be used for a variety of applications: - such as automotive, sporting goods, marine, industrial, construction, household appliances etc. polymeric composites have high strength and stiffness, light weight, low cost, low density, high toughness, and high corrosion resistance. [1] Composite materials have great potential to

improve the traditional materials like mud, wood, metal and concrete which have their own weaknesses such as heavy weight, chemical attack and poor durability. In addition, costly imported partition walls are out of the reach of most people. So the need for another high quality locally made material has become a necessity. Therefore, a new composite wall partition and false ceiling made from natural fiber are proposed in this research. Natural fiber reinforced composites have advantage over common reinforcing composites such as those using glass and carbon fibers. They also minimize the opposing impact on the environment. [5]. False banana fiber (FBF), a ligno-cellulosic fiber, obtained from the pseudo-stem of false banana plant (Musa sepientum), is a bast fiber with relatively good mechanical properties. Natural fiber (NF) from false banana is among widely used natural fibers in southern parts of Ethiopia which is available abundantly.

In the past few decades, gypsum has been used as a finishing material for walls and ceilings. Due to its excellent performance as well as high aesthetic properties, gypsum has made attractive appearance and its healthy contribution to living conditions have made most popular finishing material for applications. In addition, the availability in subsoil, relative low cost, easy handling and mechanical characteristics are suitable for different applications, making the gypsum a widely used construction material. However, gypsum has some undesirable characteristics, such as heaviness, brittleness: - impeding exterior application. Heaviness and brittleness may be appreciably reduced by combining gypsum with mineral particles or natural fiber. [2]

A lot of researches have been conducted on natural fiber reinforced polymer composites but researches on false banana fiber based polymer composites -on an isotropic gypsum resin composites is very rare. Against this background, in the present research work a noble effort has been done, with the objective of improving the mechanical and physical characterization of different fiber weight strength ratio composites. In this study, false banana fiber reinforced with gypsum to create new composite materials for application like wall partition and false ceiling, thereby optimizing fiber weight composition in gypsum. [2]

2: Methods and Materials

The given false banana fiber has been cut into fiber length, with 10cm using a pair of Scissors and finally the chopped fiber are obtained. Then it is mixed with gypsum Powder.

Fig.1: False banana Fiber Gypsum powder

2.1. False banana fiber

False banana fibers were extracted from the false banana plants using manual extraction techniques. The lower leaves of the plant, which are standing at an angle of more than 45 degrees to the vertical, are cut away from the bole of the plants with a sharp flexible knife. The peeling part are clamped between the wooden table and the knife. Then they are hand-pilled gently along the longitudinal direction in order to remove the resinous materials. Then the extracted fiber are washed gently with pure water in order to loosen and separate the fiber until the individual fibers are obtained. Finally, the extracted fibers are dried in the sunlight for three days as shown in Figure 2.

For this research work--false banana (enset) fiber as reinforcement, the study areas which are considered is southern part of Ethiopia. The extraction of the fiber was not taken place as the main objective. Rather the fiber is a byproduct.

Fig.2: Harvesting enset plant, Extraction process respectively

2.2. Gypsum

In this research an attempt has made to use Abay Gypsum as matrix. Based on the extensive literature survey, Gypsum found to be one of the most exciting polymer types and is used in advance to produce composite material with different reinforcing elements. It is extensively used mainly for its superior mechanical properties, excellent adhesion, good possibility of utilizing addition- type reaction as well as for low cure shrinkage and low cost.

3: Composite Fabrication Process

Before the reinforcement of short false banana fiber to gypsum, the fiber volume fraction and matrix volume fraction of this composite material has to be determined.

Next, the false banana fiber and matrix weight should be determined, then mixing them together by hand or by brush equally. The composite was cured at room temperature until it was dry. Finally, false banana fiber reinforced gypsum composite is fabricated.

Composite materials can be prepared by different methods. However, due to many reasons such as part size and shape, cost, familiarity with the technique and availability of tools, composite is fabricated using hand lay-up techniques. The hand lay-up is one of the oldest composite fabrication techniques and it belongs to the open mold category. The operator places the reinforcement and the resin mix manually on a mold and thereafter the resin reinforcement mixture is compressed with a hand roller as shown in figure 3.

Fig.3: Hand Lay-up technique

In this process, short false banana fiber, gypsum and water are applied to the mold by weighting electronic balance at AAiT Mechanical Engineering Workshop. A roller is used to impregnate the fiber with the resin. Another resin and reinforcement layer is applied until a suitable thickness builds up. It is a very flexible process that allows the user to optimize the part by placing different types of fabric and mat materials. This process requires less capital investment and expertise and is therefore easy to use.

Fig.4: Flexural sample to test Impact sample to test

4 Dimensions of Test Pieces

According to ASTM standard, (American Society for Testing of the Materials) test specimens were prepared and conducted the test of this false banana fiber reinforced gypsum composite to understand the mechanical behaviors and characterization.

4.1 Tensile test

The tensile test is done by cutting the composite specimen as per ASTM: D3039

standard (sample dimension is 250 × 30 × 3 mm). A universal testing machine (UTM) (Model: WAW-100 is used for testing with a maximum load rating of 100 KN. Composite specimens are tested; and the following results have been recorded:
In each case, three samples are tested and the average results are determined and noted. The load is applied until the specimen breaks and break load, tensile strengths is noted. Tensile stress and strain graph is recorded or generated and Load vs. length graphs should be generated.

4.2 Impact Test

The impact test set up consists of a pendulum which is dropped from an angle of 45 degree to impact the specimen and to fracture it. Charpy impact is employed in this impact work. The specimens are prepared as per ASTM: (Sample dimension is 55× 10 × 10 mm). Capacity of machine is 17kg/m and it is 6701 type and has E5360 number in AAiT Mechanical Material Testing Laboratory.
Composite specimens have been tested and the following results are recorded:
In each case, three samples are tested and the average is determined and noted.
The specimen must be loaded in the testing machine to allow the pendulum until it fractures or breaks:
The amount of Energy absorbed during the breaking of specimen is noted:
Using the impact test, the energy needed to break the material is noted.

4.3 Flexural Test

The flexural test is done in a three-point flexural setup as per ASTM: D3410 standard (Sample dimension is 180 × 25 × 5) mm at AAiT Mechanical Engineering Material Testing Laboratory. This test is carried out in the universal testing machine. A universal testing machine (UTM) (Model: WAW-100 is used for testing with a maximum load rating of 100 KN. When a load is applied at the middle of the specimen, it bends and fractures. Composite specimens are tested and the following results are recorded:
In each case, three samples are tested and the average is determined and noted.
Breaking load is recorded
Load vs. length graphs is generated.
Stress vs. strain graph is generated

5. Experimental Setup

All the mechanical tests were investigated using Computer Controlled Electro-Hydraulic Servo Universal Testing Machine model: WAW-100; which has a rating capacity of up to 100kN, with accuracy of 0.01 – 500 mm /min test speed.

Fig.5: Tensile test Impact test

Fig.6: Before bending after bending

6. Result & Discussion:

6.1 Tensile Properties

The tensile test is carried out by cutting the composite specimen as per ASTM: D3039 standard (sample dimension is 250 × 30 × 3 mm). A universal testing machine (UTM) (Model: WAW-100 is used for testing with a maximum load rating of 100 KN. The different three composite specimen samples are tested and the average is taken and the samples are left to break until the ultimate tensile strength occurs. Stress–strain curve is plotted for determining tensile strength, Poisson ratio, shear modulus and elastic modulus. The sample graph is generated manually from the machine used for tensile test with respect to load and displacement at AAiT Mechanical Engineering Material Testing Laboratory.

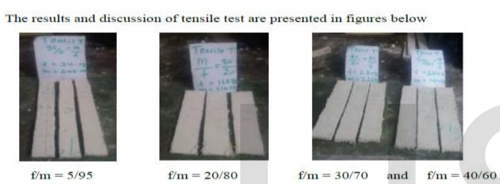

Fig 7: Specimens of composite

Where: - f/m represents :(f) for false banana fiber and (m) for matrix (gypsum) or Fiber to gypsum ratio

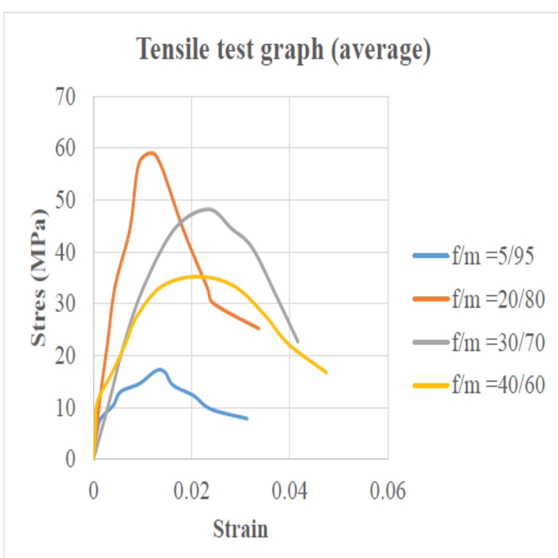

Fig 8: Stress-strain diagrams for different wt. % of false banana fibers on tensile test

Table 1: Summary table for tensile test result (9, 21)

Samples of Composite	Length (mm)	Width (mm)	Thickness (mm)	F_{max} (KN)	Tensile strength (MPa)	Modulus Elasticity (MPa) E	Shear modulus (GPa) G	Poisson ratio (υ)
FBF-5	250	30	3	1.7	17.04	1331.019	0.55229	0.205
FBF-20	250	30	3	9.67	59.01	4879.548	2.25931	0.22
FBF-30	250	30	3	5.33	48.15	2056.471	0.83637	0.23
FBF-40	250	30	3	3.5	35.19	1652.43	0.66630	0.24
glass fiber with epoxy					2000	70,000	15	0.25

6.2 Impact Properties

Three same samples are prepared to test for each fiber composition and the average of the three is taken. The specimens are prepared as per ASTM: D256 standards. A universal testing machine, at AAiT Mechanical Engineering Testing Laboratory was used for testing. The specimens are shown in Figure 4. The specimen must be loaded onto the testing machine to allow the pendulum until it fractures or breaks. Using the impact test, the energy needed to break the material is noted. The loss of energy during impact is the energy absorbed by the specimen during impact.

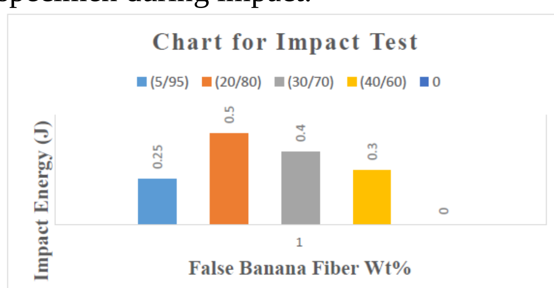

Fig 9: Chart that shows impact energy result

Table 2: Impact properties of false banana fiber filled gypsum composite.

False Banana Fiber Wt.%	Dimensions (Mm)			Impact Energy (J)
	Length	Width	Thick	
Fbf-5	55	10	10	0.25
Fbf-20	55	10	10	0.5
Fbf-30	55	10	10	0.4
Fbf-40	55	10	10	0.3

6.3 Flexural Properties

The flexural test is done in a three-point flexural setup as per ASTM: D3410 standard (sample dimension is 180 × 25 × 5) mm). A universal testing machine (UTM) (Model: WAW-100 is used for testing with a maximum load rating of 100 KN. When a load is applied at the middle of the specimen, it bends and fractures. Test results include load and displacement, stress vs. strain and load vs. displacement curve is plotted for the determination of flexural strength

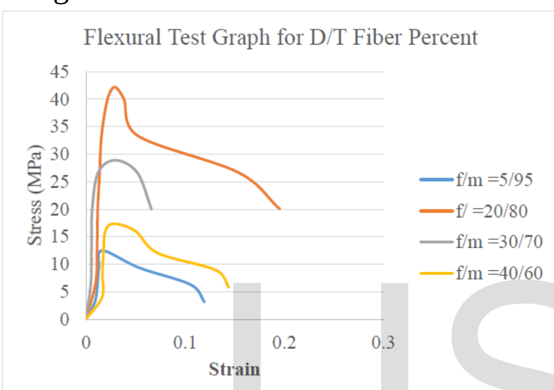

Fig 10: Stress-strain diagrams for different wt. % of false banana fibers on flexural

Table 3: Summary table for flexural test (9, 21)

Samples of Composite	Length (mm)	Width (mm)	Thickness (mm)	F_{max} (KN)	Flexural Strength (MPa)	Modulus Elasticity (MPa) E	Shear Modulus (GPa) G	Poisson Ratio (υ)
FBF-5	180	30	5	0.933	12.44	754.21	0.31295	0.205
FBF-20	180	30	5	3.166	42.22	1470.96	0.60285	0.22
FBF-30	180	30	5	2.166	28.88	983.61	0.39984	0.23
FBF-40	180	30	5	1.3	17.33	610.57	0.246197	0.24
glass fiber with epoxy					2000	70,000	15	0.25

7. Conclusions

The aim of this study was to obtain the optimum mechanical and physical properties of the composite materials prepared from the fibers of the plant false banana (Enset Ventricosum) reinforced with gypsum for specific application. The false banana fiber was extracted manually from Ethiopian southern part false banana plant. Next, false banana fiber reinforced gypsum composite was manufactured for each weight ratio of 5/95%, 20/80%, 30/70%, and 40/60% where it was determined experimentally. All the numerous experimental test results were gathered from important information about chopped false banana fiber reinforced gypsum composite. Based on the test, results were obtained from the various tests carried out, and afterwards, conclusions were made:

A polymer matrix composite contains the chopped false banana fiber as a reinforcement was successfully fabricated and from the tensile, flexural and impact test results where it is found that 20/80 wt.% have better mechanical property among the other fiber-matrix composition. Tensile and flexural strength, Modulus of elasticity, load and shear modulus in 20wt% have better than the others 5, 30, and 40wt% false banana fiber compositions. So 20/80 specimen is better than the others false banana fiber composition.

Finally, the result obtained was compared with glass fiber reinforced epoxy standard specimen, of no additives. As shown in tables 1 and 3, the false banana fiber reinforced gypsum composite cannot be compared with glass fiber reinforced epoxy composite because glass fiber reinforced epoxy composite has very higher mechanical properties but almost similar with other natural fibers like sisal fiber reinforced epoxy composite.

Therefore, from all the results and comparisons, this research can conclude that the fabricated chopped false banana fiber reinforced gypsum composites have a good mechanical property and it is recommended to use it for light weight application, like for the production of false ceiling and wall partition which are used for interior decoration for both the domestics as well as industrial application as construction material which definitely replaces the existing material in terms of cost and efficiency.

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