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AN ANALYSIS ON THE EFFECT OF FIBER VOLUME FRACTION ON PHYSICAL AND MECHANICAL PROPERTIES OF NATURAL FIBER COMPOSITES

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ABSTRACT

At present, natural fibers are the renewable resources of reinforcing material for the production of composite material. This analysis report provides the analysis data on the effect of fiber volume fraction on the physical and mechanical properties of natural fiber composite. Composite is fabricated by using jute, hemp, and coconut fiber as a reinforcing material and phenol-formaldehyde as an adhesive material. The conclusion of this analysis is at 40% fiber volume fraction the moisture inside the composite, water absorbed by the composite during the water absorption test, and expansions in length, width, and thickness are found minimum. Modulus of elasticity found maximum at 50% fiber loading.

Keywords: Physical properties, Mechanical properties, Phenol formaldehyde resin

1. INTRODUCTION

This chapter provides all the basic information related to composites.

1.1 Overview of Composites

The development in ecological mindfulness and society intrigue, the new natural law, and the insufferable utilization of oil prompted thinking about the use of earth amicable materials. The regular fiber is viewed as one of the naturally well-disposed materials which have great properties contrasted with engineered fiber.

1.2 Definition of Composites

A composite material is a material that is fabricated from two or more than two materials with considerably extraordinary synthetic and physical properties that when they joined, manufacture a material with an alternate property from the individual materials.

1.3 Classification of Composites

Classifications on composites are as follows

a) Classification based on the matrix material
   - Metal matrix composite
   - Ceramic matrix composite
   - Polymer matrix composite

b) Classification on the basis on reinforced material
   - Fiber-reinforced composite
   - Particle reinforced composite

1.4 Advantages of Composite Material

Some advantages of composite material over the conventional one are as follows:

1) The tensile strength of the composite is two to four times greater than that of steel (depending on the reinforcement).
2) The impact properties and torsional stiffness are high of composite material.
3) Composite produces less noise during the time of operation and provides minimum vibration transmission than metals.
4) Electrical insulation property is outstanding for the composite.
5) Impact resistance is high.
6) Low material cost.
7) The resistance of corrosion.

1.5 Application area of composites

Applications of the composite are as follows

1) In aircraft, it is used in the door skin on the stabilizer box fin, in elevators.
2) In automobiles, it is used to make body frame, chassis components.
3) In electrical it is used to make a printed circuit board.
4) It is used to make pipe and water tanks.
5) It is also used for making furniture.
6) It is also used for making particleboard.

2. LITERATURE REVIEW

This chapter provides information about recent work done in the field of physical properties of natural fiber composites. For composite material, its physical properties depend upon many aspects such as fiber volume ratio, the orientation of fiber, fibers length.

C. Capela et al (1) researched the impact of fiber length on the mechanical properties of high dose carbon-fortified by utilizing short carbon filament fortifications by taking 2, 4 and 6 mm fiber length with 60% weight fiber portion. The finish of this exploration was solidness increments to 25% when fiber length increments from 2mm to 4mm yet a while later reductions from 6mm fiber length composite.

Himanshu Bisaria et al (2) researched the impact of fiber length on mechanical properties of arbitrarily arranged short jute fiber composite by taking 30% weight division with different fiber lengths of 5, 10, 15, and 20mm. The finish of this examination is at 15mm fiber length tractable and flexural properties were discovered most extreme and effect properties were discovered greatest ate 20mm fiber length with 30% weight portion.

Hari Om Maurya et al (3) concentrate on the mechanical properties of the epoxy composite utilizing short sisal fiber. In this examination, the composite was set up with different fiber lengths (5, 10, 15, and 20mm) with a 30% fiber proportion. The finish of this exploration was at 15mm fiber length flexural quality improved 25% and at 20mm fiber length, sways properties improved.

Wim Nhuapeng et al (4) learn about the mechanical properties of half breed composites by taking different fiber proportions that are as per the following 25wt%, 30wt%, 40wt%, and 50wt%. The finish of this exploration was the example of 25wt% and 30wt% show the best mechanical properties though the 40wt% indicated phenomenal sound properties.

Prakash Marimuthu K et al (5) examined the portrayal of mechanical properties of the composite material by utilizing coconut and glass fiber. The example is arranged by taking 10% glass fiber, 30% coconut fiber, and 60% epoxy sap. The finish of this examination was a portion of the mechanical properties like thickness, elasticity, and miniaturized scale hardness is influenced when coconut fiber is included yet sway quality expanded. The hardness of the composite material expanded.

J.A. Flores et al (6) explored pressure sway on regular reed particleboard fabricating utilizing destroying sharp edges. Urea-formaldehyde resin use as matrix material. This examination presumes that when weight fluctuating 3N/mm^2 to 25N/mm^2. The outcome permitted us to express that pressure and the Molecule size assume a significant job in improving the mechanical properties of the particleboard.

Ashish Kumre et al (7) examined the change in mechanical properties of sisal glass fiber fortified composite by supplanting manufactured fiber to normal fiber by taking fiber different lengths (5, 10, 15, and 20mm). The end was the rigidity not expanded however ductile modulus, sway properties were improved.

Sunil Singh Rana et al (8) researched the impact of minor departure from mechanical properties in the fortified composite. The composite is arranged by hand lay-up technique by utilizing the different fiber lengths (5, 10, 15, and 20mm) by fixed fiber proportion that is 30wt%. The outcomes show the capacity modulus and are discovered high at 15mm fiber length.

F. Rezaei et al (9) explored the impact of the length of fiber on the thermo-mechanical attribute of carbon fiber composites by setting up the example by hot squeezing method. The end came out by performing warm gravimetric investigation and dynamic mechanical examination and results show that when fiber length expanded warm dependability expanded and damping properties improved.

Tiesong Lin et al (10) explored the impact of fiber length on mechanical and crack conduct of geopolymer grid composite by taking different fiber lengths (2, 7, and 12mm). In the wake of examining by three bowing tests, optical magnifying instrument, and checking electron microscopy the outcome shows that at 7mm fiber length show as the most extreme flexural quality just as the most elevated work of crack.

3. MATERIAL SELECTION

There are two types of material are used for the sample preparation first one is reinforced which is a natural fiber and the second one is matrix material which is phenol-formaldehyde. The materials which are used in this research are as follows.

- Coconut Fiber
- Jute Fiber
- Hemp Fiber
- Phenol-Formaldehyde resin

3.1 Coconut Fiber

Coir, or coconut fiber, is a characteristic fiber extricated from the external husk of coconut and utilized in items, for example, floor mats, mats, brushes, and sleeping pads. Coir is the stringy material found between the hard, interior shell and the external layer of coconut.

Properties

The properties of coconut fiber are as follows

1. The diameter of the coir fiber is 0.15 to 1.6.
2. The length of fiber is 5 to 7 inches.
3. The strength of coir fiber is high.
4. It is a renewable source of fiber.
5. It is highly flammable.

Applications

The applications of coir fiber are as follows

1. Use for making Rope.
2. Use for making composites.
3. Use for making sofas sheet.
4. Use for making carpets.

3.2 Jute Fiber

Jute fibers are made fundamentally out of the plant materials cellulose, lignin, and gelation. Both the fiber and the plant from which it comes are generally called jute.

Properties

The properties of jute fiber are as follows

1. Good thermal conductivity.
2. Biodegradable.
3. Jute fiber length is 5 to 10 feet.
4. Strength is high.

Applications

Applications of jute fiber are as follows

1. Use for making rope.
2. Use for packing product.
3. Use for making carpets.
4. Use for making composite.

3.3 Hemp Fiber

The fiber is one of the most important pieces of the hemp plant. It is normally called bast, which alludes to the strands which develop outwardly of the plant's tail. Bast fiber invigorates the plants. Hemp strands can be between roughly 0.91 m (3 feet) and 4.6 m (15 feet) long, running the length of the plant.

3.4 Phenol Formaldehyde resin

Utilized as the reason for Bakelite, PFs were the main business manufactured pitches (plastics). They have been generally utilized for the creation of shaped items including billiard balls, research center ledges, and as coatings and glues.

These thermosetting tars are gotten by responding to phenol C_6H_5OH and formaldehyde CH_2O. Formaldehyde structures $-CH_2-$ spans between two phenol atoms, creating chains. Straight chains are gotten when the response proportion is 1:1. Phenol, notwithstanding, may likewise respond with a third formaldehyde atom. At whatever point this occurs, a branch is shaped in the chain. One potential response arrangement has appeared in the upper left plan.

Properties

Properties of PF resin are as follows

1. Low density.
2. High durability.
3. Dimensional accuracy is good.
4. High creep resistance.
5. Water absorption behavior is low.

4. SAMPLE COMPOSITIONS

In this study, composite samples are fabricated by fixing fiber length 12mm and varying the fiber volume ratios. The compositions of the samples are as follows.

- **S1** sample contains a 30% fiber volume ratio with 12mm fiber length.
- **S2** sample contains a 40% fiber volume ratio with 12mm fiber length.
- **S3** sample contains a 50% fiber volume ratio with 12mm fiber length.
- **S4** sample contains a 60% fiber volume ratio with 12mm fiber length.

Total three types of fiber are uses for fabricating the sample the amount of each fiber are equal for example in **S1** sample jute fiber is 10%, coconut fiber is 10%, and Hemp fiber is 10%.

Fig. (Composite specimen)

5. TESTING AND TESTING RESULTS

During this research both physical and mechanical properties are tested which are as follows:

5.1 Physical Properties Tests

For the investigation, the physical properties of composites given tests are performed which are as follows:

5.1.1 Density Test

For density test specimen dimensions for all samples are length is 15cm, width is 7.5cm and the thickness is 0.5cm.

5.1.2 Moisture content test

For moisture content test the sample dimensions for all samples are thickness is 0.5cm, the length is 15cm and width is 7.5cm.

5.1.3 Water soak test

This test performs for 2 and 24 hours and the dimensions of samples are thickness is 0.5, length and width are 15cm.

5.1.4 Expansion in dimensions

This test provides the changes in thickness, width, and length during the swelling in water test. Specimen dimensions are length is 15cm, width is 7.5cm with 0.5cm thickness.

Table 5.1 Observation table for physical property tests analysis

Sl. No	Density (gm/cm^3)	Moisture Content (%)	Water absorption for 2 hours (%)	Water absorption for 24 hours (%)	Length expansion (%)	Width expansion (%)	Thickness expansion (%)
S1	0.689	4.70	15.13	34.52	0.22	0.21	4.2
S2	0.692	4.64	14.71	33.80	0.24	0.25	4.6
S3	0.680	4.90	15.21	36.59	0.26	0.29	5.2
S4	0.682	5.06	15.30	37.80	0.28	0.31	6.2

5.2 Mechanical Properties Tests

For an investigation of mechanical properties the test which is tested are as follows:

5.2.1 Modulus of Elasticity

For testing the modulus of elasticity of composite the dimension of all specimens are width is 5cm, the thickness is 0.5cm and length is 24 times of thickness.

5.2.2 Modulus of Rupture

For performing this test the dimensions of all samples are the same as which is used in modulus of elasticity test.

Table 5.2 Observation table for mechanical property tests analysis

Sl. No	Modulus of Elasticity (N/mm^2)	Modulus of Rupture (N/mm^2)
S1	598.21	12.21
S2	605.18	12.28
S3	622.62	13.32
S4	612.35	14.13

6. CONCLUSION

Fabrication of composite by using phenol-formaldehyde as adhesive material and natural fiber as reinforced material has been done. All the tests are tested and after study, all tests some conclusions are found which are as follows:

1. At 40% of the fiber volume ratio, the density is found maximum.
2. The moisture present in composite minimum at 40% fiber volume ratio.
3. For the 2 and 24-hour water, absorption test the sample of 40% fiber volume ratio is absorbed minimum water.
4. Expansion in length, width, and thickness found a minimum at 30% fiber volume ratio composite.
5. At 50% fiber volume ratio the modulus of elasticity is found maximum.
6. At 60% fiber volume ratio modulus of rupture found maximum.

7. FUTURE WORK

After study the conclusion of this research there is some future work came out which are as follows

1. We can replace epoxy resin to urea-formaldehyde resin as well as phenol-formaldehyde resin.
2. We can fix the fiber length and varying the fiber ratio.
3. We can fix the fiber ratio and varying the fiber length.
4. We can change the orientation of the fiber.

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