INVESTIGATION ON THE MECHANICAL PROPERTIES OF MADAR FIBER REINFORCED IN POLYMER MATRIX COMPOSITES

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Abstract - Bio fibers had recently become eye catching for the scientists and engineers due to its high mechanical strength. In this present work, newly identified madder fiber is used for making composite material the fiber is extracted from the stem by manual process. The fiber is separated into small parts and then it is mixed with polyester resin. Five plates were going to be made by 20%, 30%, 40%, and 50% by mass of the fiber. The mechanical properties of the plates such as tensile strength, compressive strength, impact strength and compressive strength of each plate was tested.

keywords—madar fiber, polyester resin,

1 INTRODUCTION

Composite are combination of two or more than two materials in which one of the material, is reinforcing phase/polymer, metal or ceramic) composite material are usually classified by type of reinforcement such as polymer composite, cement and metal matrix composite polymer matrix composite are mostly commercially produced composites in which resin is used as matrix with different reinforcing material. Polymer (resin) is classified in two types thermoplastic (PE, PP, PEEK, PVC, PS, Polyolefins etc) and thermo set (epoxy, polyester and phenol-formaldehyde resin etc) which reinforces different type of fiber like natural (plant, animal, mineral) and manmade fiber for different application. Composites are now extensively being used for rehabilitation/strengthening of pre-existing structures that have to be retrofitted to make them seismic resistant, or to repair damage caused by seismic activity. Unlike conventional materials (e.g., steel), the properties of the composite material can be designed considering the structural aspects. Composite materials are broadly, classified into three groups on the basis of matrix material. They are

- Fiber reinforced polymer (FRP)
- Particle reinforced polymer (PRP)

1.1 Natural fiber composites:

The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocellulose fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. The natural fiber-containing composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling paneling, partition boards), packaging, consumer products, etc. The term “natural fibers” covers a broad range of vegetable, animal, and mineral fibers. However, in the composites industry, it usually refers to wood fiber and agro based bast, leaf, seed, and stem fibers. These fibers often contribute greatly to the structural performance of the plant and, when used in plastic composites, can provide significant reinforcement. One of the largest areas of recent growth in natural fiber plastic composites is the automotive industry, particularly in Europe, where natural fibers are advantageously used as a result of their low density and increasing environmental pressures. Increased technical innovations, identification of new applications, continuing political and environmental pressures, and government investment in new methods for fiber harvesting and processing are leading to projections of continued growth in the use of natural fibers in composites, with expectation of reaching 100,000 tons per annum.

Two types of polymer composites are
1.2 Classification of natural fibers:

Composites, due to their heterogeneous composition, provide unlimited possibilities of deriving any characteristic material behavior. This unique flexibility especially molding to any shape with polymer composites, repair ability, corrosion resistance, durability, adaptability and cost effectiveness, etc. have attracted the attention of many users in several engineering applications. Cellulose fibers are flexible but possess high strength. The more closely packed cellulose provides higher density and higher strength. The walls of these hollow elongated cells are the primary load-bearing components of trees and plants. Depends on the cellulose content the composites are classified as

![Classification of natural fibers](image)

1.3 Advantages of Composites:

Advantages of composites over their conventional counterparts are the ability to meet diverse design requirements with significant weight savings as well as strength-to-weight ratio. The biggest advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. Composites also provide design flexibility because many of them can be molded into complex shapes. The downside is often the cost. Although the resulting product is more efficient, the raw materials are often expensive.

Some advantages of composite materials over conventional ones are as follows:

- Tensile strength of composites is four to six times greater than that of steel or aluminum (depending on the reinforcements).
- Improved torsional stiffness and impact properties.
- The mechanical performance of natural fiber reinforced plastics varies greatly depending on the type of natural fibers, fiber treatments, and the type of plastic, additives, and processing methods.
- Higher fatigue endurance limit (up to 60% of ultimate tensile strength).
- 30% - 40% lighter for example any particular aluminum structures designed to the same functional requirements.
- Lower embedded energy compared to other structural metallic materials like steel, aluminum etc.
- Composites are less noisy while in operation and provide lower vibration transmission than metals.
- Composites are more versatile than metals and can be tailored to meet performance needs and complex design requirements.
- Long life offer excellent fatigue, impact, environmental resistance and reduce maintenance.
- Composites enjoy reduced life cycle cost compared to metals.
- Composites exhibit excellent corrosion resistance and fire retardance.
- Improved appearance with smooth surfaces and readily incorporable integral decorative melamine are other characteristics of composites.
- Composite parts can eliminate joints / fasteners, providing part simplification and integrated design compared to conventional metallic parts.

2. MATERIALS AND METHODS

Fiber used

![Calotropis plant](image)

**calotropis**

Akund floss, also called calotropis floss, ask, madar, or mader, downy seed fiber obtained from *Calotropis procera* and *C. gigantea*, milkweed plants of the *Apocynaceae* family (formerly in *Asclepiadaceae*). Small trees or shrubs, these two species are native to southern Asia and Africa and were introduced to South America and the islands of the Caribbean, where they have naturalized. The yellowish material is made up of thin fibers 2 to 3 cm (0.8 to 1.2 inches) long and 12 to 42 microns (a micron is about 0.00004 inch) in diameter and is harvested from the seeds by
hand. While akund floss has been used primarily as upholstery stuffing and is sometimes mixed with the seed fibre kapok, it has development potential as a new ecological material.

Calotropis yields a durable fiber (commercially known as Bowstring of India) useful for ropes, carpets, fishing nets, and sewing thread. Floss, obtained from seeds, is used for stuffing purposes. Fermented mixture of Calotropis and salt is used to remove the hair from goat skins for production of "nari leather" and of sheep skins to make leather which is much used for inexpensive book-binding (Singh et al. 1996). Fungicidal and insecticidal properties of Calotropis have been reported. Ganapathy and Narayanasamy (1993).

2.1 Fiber extraction process

Fiber extraction process of the madar fiber is usually done by the help of water retting process. In this process the stem with high fiber and lignin content is placed in a water body for 6 to 8 days. The water body may running water body as rivers or stagnant one like lake. During this period microbial action takes place in stem and leads to separation of fibers and thus finally fiber is extracted by water retting process.

2.2 Resin used

A polyester resin is comprised of an unsaturated backbone polymer dissolved in a reactive monomer. The polyester backbone polymer is formed by condensation of a mixture of dibasic acids (saturated and unsaturated) and one or more glycols. Vinyl-ester resins are high performance polyester resins, which are acrylic esters of epoxy resins dissolved in styrene monomer. Polyester resins can be reinforced with almost all types of reinforcements to make polyester composites. Polyester resins are cheaper and more versatile, but inferior to epoxy resins in some respects. Polyester resin material is a three-component material. However, the manufacturer mixes the two reactive parts. At the time of application, a catalyst is added to start the reaction. Then the material is sprayed onto the roadway. The material has the potential to be 100 percent solid. This depends on how fast the reaction takes place. The styrene is volatile prior to the reaction. Heat is not typically added to the system except when cure time is expected to be long, such as on cool spring or fall days. The catalyst is added to drive the reaction. Usually, the catalyst is methyl ethyl ketone (MEK) or benzoyl peroxide. The polyester resin and the styrene solvent react together to crosslink, or polymerize, to form a film. The polyester resin system will not cure properly if the appropriate quantity of catalyst is not added.

4.4 Polymer-Hardener Mixture Preparation

A measured amount of polymer was taken for different volume fraction of fiber composite and mixed with the hardener in the ratio 4:1. The mixture was stirred properly for uniform mixing. Care was taken to avoid formation of bubbles.

4. PREPARATION OF COMPOSITES

For the sample preparation the first and foremost step is the preparation of the mold which ensures the dimension of 300x300x30 mm the composite to be prepared. We have to prepare molds for the preparation of 10%, 20%, 30%, 40%, 50%, fiber of the composite. A clean smooth surfaced wooden board is taken and washed thoroughly. The Steel plate was covered with a mold release sheet. After the mold preparation the grass fibers are placed in the mold and then the polyester hardener mixture is poured gently for each molds for making five plates with different volume fraction such as 10%, 20%, 30%, 40%, and 50%. Then the mold is set at room temperature for 24 hours. Care should be taken to avoid bubbles as if bubbles produced will affect the plate formed. The fibers are aligned in unidirectional for producing composites.

3. CASTING

The madar fiber prepared in the above steps were put on the already designed mold. After putting the madar fiber in the mold, the polymer-hardener mixture was slowly poured over it. Madar fiber due to its light weight and high volume gets swelled up. For that reason only we roll a roller gently till the sample fits in the mould. Then we cover the sample with a non-reacting plastic cover and place the glass on it such that no voids or air gaps leave behind. These voids weaken the composite and makes testing difficult. For the composite of perfect dimension weight should be carefully put above it. Weight should be put in such a way that no polymer hardener mixture seeps out of the glass.

The composite sheet takes 24 hrs. for curing in room temperature. Then the samples were cut into desired dimensions for experimental purposes depending on the standards.
In this work the fabrication of composite plate is done by taking the fiber orientation as random discontinuous. While preparing sample the mold should be prepared in the dimension of 300×300×3mm. A flat plate is placed and it’s applied with wax and OHP sheet is placed over it. In this flat surface the prepared mold is placed and the fiber resin mixture for the different composition such as 20%, 30%, 40% and 50% of fiber were poured over it and made to spread over the entire mold and the OHP sheet is placed over it, over this is a flat surface is placed. Then we cover the sample with a non-reacting plastic cover and place the glass on it such that no voids or air gaps leave behind. These voids weaken the composite and makes testing difficult. For the composite of perfect dimension weight should be carefully put above it and finally large amount of uniformly distributed load is placed over it to get the smooth surface.

4.2 Testing of composites:

4.2.1 Tensile test:

The prepared composite plates are cut by saw cutting to get the dimensions of the specimen for tensile testing as per ASTM standards of 165×25×3 mm and the test was carried out by using universal testing machine. The specimens are gripped in the universal testing machine and the test results are noted with respect to strain till the specimen gets fractured. Shown in Fig 5

![Fig.5 Tensile testing machine](image)

4.2.2 Flexural test:

Flexural test exhibits the behavior of the material when subjected by the maximum stress applied in it. The specimens are cut by saw cutting as per the ASTM standards of 125×12.5×3 mm. The specimen loaded on its midpoint when it is subjected to simple beam loading, the flexural test used to determine the maximum stress induced in the material. Shown in Fig 6

![Fig.6 flexural testing machine](image)

4.2.3 Impact testing:

Impact test shows that the maximum energy absorbed by the material when impact load subject on it. The specimen are cut by the saw cutting as per the ASTM standards of 62.5×12.5×3mm. the specimen was gripped in the impact testing machine with charpy arrangement and the sudden impact load is subjected by the pendulum until it fractures and the corresponding energy absorbed by the material was noted. Shown in Fig 7

![Fig.7 Impact testing machine](image)

4.2.4 Compressive testing:

The prepared composite plates are cut by saw cutting to get the dimensions of the specimen for compressive testing as same as tensile testing as per ASTM standards of 165×25×3 mm and the test was carried out by using universal testing machine. The specimens are gripped in the universal testing machine and the test results are noted with respect to strain till the specimen gets fractured. Shown in Fig 8

![Fig.8 Compressive testing machine](image)
5. Results and discussion:

**Tensile strength:**
Initially the tensile strength values increase from 20% fiber to 40% fiber plate and finally decreased at 50% fiber plate. The is shows that the tensile strength value is better at 60% resin and 40% fiber plate.

![Fig.9 Tensile strength](image)

<table>
<thead>
<tr>
<th>Fiber to resin ratio</th>
<th>Tensile strength</th>
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<tbody>
<tr>
<td>50/50</td>
<td>21.3</td>
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<tr>
<td>40/60</td>
<td>38.4</td>
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<td>30/70</td>
<td>34.82</td>
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<td>20/80</td>
<td>25.72</td>
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**Flexural Strength:**
The flexural strength value for the mader fiber increase initially from 20% fiber plate to 40% fiber plate and suddenly decreased at 50% fiber and 50% resin plate. This implies flexural strength value is better at 60% resin and 40% fiber.

![Fiber to resin ratio vs Flexural Strength](image)

<table>
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<th>Flexural strength</th>
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<tbody>
<tr>
<td>50/50</td>
<td>38.3</td>
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<tr>
<td>40/60</td>
<td>56.2</td>
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<td>30/70</td>
<td>44.7</td>
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<td>20/80</td>
<td>34.6</td>
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**Impact strength:**
The impact strength value of the mader fiber value increase from 20% fiber plate to 40% fiber plate and then suddenly decrease at 50% fiber and 50% resin plate. This shows that impact strength value better at 60% resin and 40% fiber plate.

![Impact strength in J](image)

<table>
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<tr>
<th>Fiber to resin ratio</th>
<th>Impact strength</th>
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<tr>
<td>50/50</td>
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<td>40/60</td>
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<td>1.576</td>
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**Compressive strength**
The compressive strength value of the mader fiber increase from 20% fiber plate to 40% fiber plate and suddenly...


6. CONCLUSION

In this work the newly extracted madar fiber is extracted from stem of the plant by manual process. It finally is subjected to investigation of mechanical properties such as tensile strength, compressive strength, impact strength, and flexural strength.

1. The tensile strength value is better at 60% resin and 40% fiber is 38.4 Mpa.
2. The compressive strength is better at 60% resin and 40% fiber is 45 Mpa.
3. The flexural strength value is better at 60% resin and 40% fiber is 45 Mpa.
4. The impact strength value is better at 60% resin and 40% fiber is 2.722

Thus the madar fiber is renewable and is found all over the world this fiber can be used to prepare composite material for automobile.

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Table.4

<table>
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<th>Fiber to resin ratio</th>
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<td>20/80</td>
<td>26.8</td>
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</tbody>
</table>
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