# Mechanical Characterisation of Glass Fibre with Aluminium and Sugarcane Fiber

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***Abstract- Modern machines need advanced materials for better utilization and efficiency. For such need, field of material science is doing large scale research and development to find new materials. Along with better utilization modern engineering need materials that are eco- friendly and long-lasting. Increase of environmental awareness has led to a growing interest in researching ways of an effective utilization of materials such as sugarcane fiber. It is felt that the value of this residue can be upgraded by bonding with resin to produce composite suitable for applications. Fiber metal laminates are good candidates for advanced aerospace structural applications due to their high specific mechanical properties especially fatigue resistance. Keeping this in view the work proposes to develop a metal matrix composite and to study its mechanical behavior. The composite is prepared with different materials like using glass fiber with aluminum and sugarcane fiber. In the next stage of project, mechanical tests like Tensile, Compression and Impact tests will be carried out based on ASTM standards to study the effects of interfacial adhesive bonding on behavior of the laminates. Based on tests results, finally conclusion is obtained for the project***

## INTRODUCTION

Basic requirements for the better performance efficiency of an aircraft are high strength, high stiffness and low weight. The conventional materials such as metals and alloys could satisfy these requirements only to a certain extent. This lead to the need for developing new materials that can whose properties were superior to conventional metals and alloys, were developed. A composite is a structural material which consists of two or more constituents combined at a macroscopic level. The constituents of a composite material are a continuous phase called matrix and a discontinuous phase called reinforcement.

## EXAMPLES

### 1.1.1 NATURAL COMPOSITES

Wood: Cellulose fibers bound by lignin matrix Bone: Stiff mineral "fibers" in a soft organic matrix permeated with holes filled with liquids

### 1.1.2 MAN-MADE COMPOSITES

- Plywood: Several layers of wood veneer glued Together
- Fiberglass: Plastic matrix reinforced by glass fibers

The most commonly used advanced composites are polymer matrix composites. These composites consist of a polymer such as epoxy, polyester, urethane etc., reinforced by thin-diameter fibers such as carbon, graphite, aramids, boron, glass etc. Low cost, high strength and simple manufacturing principles are the reason why they are most commonly used in the repair of aircraft structures.

To measure the relative mechanical advantage of composites, two parameters are widely used, namely, the specific modulus and the specific strength. These two parameter ratios are high in composites. In the highly competitive airline market, using composites is more efficient. Though the material cost may be higher, the reduction in the number of parts in an assembly and the savings in the fuel cost makes more profit. It also lowers the overall mass of the aircraft without reducing the strength and stiffness of its components.

## METHODS

### 1.2 SPRAY LAY-UP

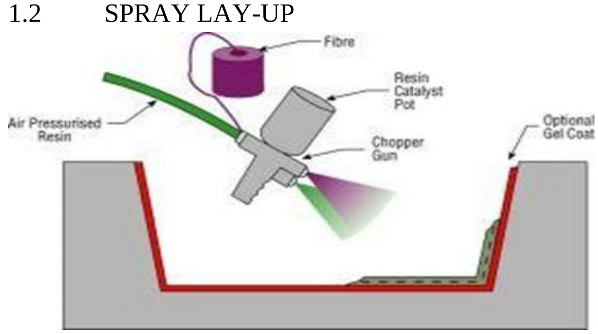


Figure 1-4: Spray Lay-up

1.2.1 DESCRIPTION

Fiber is chopped in a hand-held gun and fed into a spray of catalyzed resin directed at the mould. The deposited materials are left to cure under standard atmospheric conditions.

1.3 HAND LAY-UP

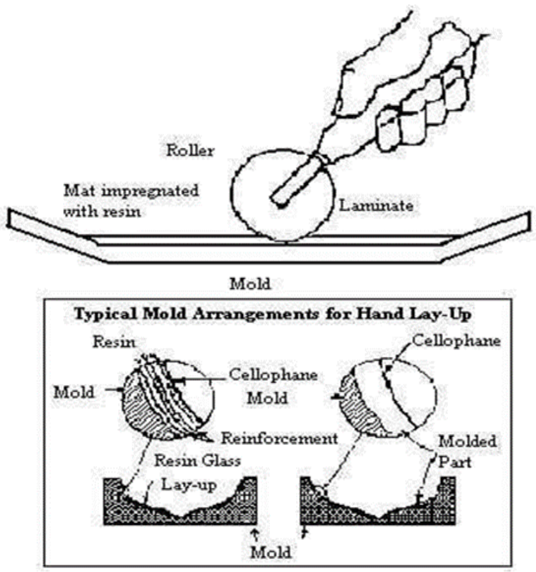


Figure 1-5: Hand Lay-up

1.3.1 DESCRIPTION

Resins are impregnated by hand into fibers which are in the form of woven, knitted, stitched or bonded fabrics. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fabrics by means of rotating rollers and a bath of resin. Laminates are left to cure under standard atmospheric conditions.

1.4 VACUUM BAGGING

1.4.1 DESCRIPTION

This is basically an extension of the wet lay-up process described above where pressure is applied to the laminate once laid-up in order to improve its consolidation. This is achieved by sealing a plastic film over the wet laid-up laminate and onto the tool. The air under the bag is extracted by a vacuum pump and thus up to one atmosphere of pressure can be applied to the laminate to consolidate it.

METHODOLOGY

The specimens were prepared with the glass fiber epoxy laminates with Aluminum alloy and sugarcane crushed into powder form according to the ASTM standard. The specimens were undergoing for mechanical testing by Universal testing machine and Impact testing machine. These results were compared with and without aluminum alloy and sugarcane mixture.

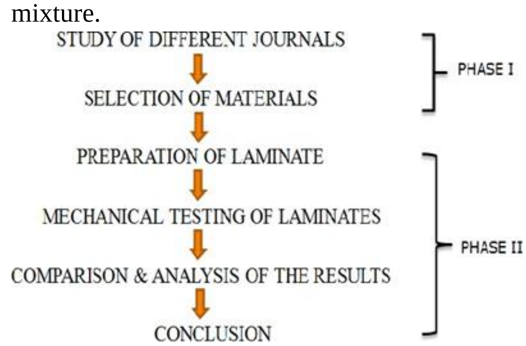


Figure 3.1: Methodology LAMINATE MATERIALS AND METHODS

This chapter describes the materials and methods used for the processing of the composites under this investigation. It presents the details of the characterization and tests which the composite samples are subjected to.

4.1 GFRP LAMINATE

In this laminate,

REINFORCEMENT - Glass Fiber Reinforcement Plastic (bi- directional type)

E-glass. MATRIX- Epoxy.

Correct ratio of resin and hardener is 10:1

Resin : LY556 Hardener : HY951

4.1.1 GLASS FIBER REINFORCEMENT PLASTIC

Glass is one of the oldest known man-made materials; the practical strength of glass, however, has always been a limiting and puzzling factor. Still today the mechanical properties of glass fibers are twofold a) a special quality is the high strength

b) the brittle fracture is limiting its application. An understanding of the structure of glass in relation to how and why it breaks is crucial in both improving existing applications of glasses and in new functionalities and application of all kinds of glasses, not only fiber glass.

- Fibers of glass are produced by extruding molten glass, at a temperature around 1200C through holes in a spinneret with diameter of 1 or 2 mm and then drawing the filaments to produce fibers having diameters usually between 5 to15μm
- The fibers have low modulus but significantly higher stiffness
- Individual filaments are small in diameters, isotropic and very flexible as the diameter is small.
- The glass fibers come in variety of forms based on silica(SiO2) which is combined with other elements to create speciality glass.

4.2 TYPES OF GLASS FIBRES

- E glass - high strength and high resistivity
- S2 glass - high strength, modulus and stability under extreme temperature and corrosive environment.
- R glass – enhanced mechanical properties
- C glass - resists corrosion in an acid environment

4.3 EPOXY

Epoxies are polymer materials, which begin life as liquid and are converted to the solid polymer by a chemical reaction. An epoxy based polymer is mechanically strong, chemically resistant to degradation in the solid form and highly adhesive during conversion from liquid to solid. These properties, together with the wide range of basic epoxy chemicals from which an epoxy system can be formulated, make them very versatile.

Epoxy systems physically comprise two essential components, a resin and a hardener. Sometimes there is a third component, an accelerator, but this is not so common. The resin component is the ‘epoxy’ part and the hardener is the part it reacts with chemically and is usually a type of ‘amine’. Whereas the resin component is usually light, sometimes almost clear coloured and near odourfree, hardeners are usually dark and have a characteristic ‘ammonia-like’ odour. When these two components are brought together and mixed intimately in a prescribed way, they will react chemically and link together irreversibly, and when the full reaction has been completed they will form a rigid plastic polymer material.

4.4 ALUMINIUM

Aluminium has a unique and unbeatable combination of properties that make it into a versatile, highly usable and attractive construction material.

4.4.1 Weight

Aluminium is light with a density one third that of steel, 2.700 kg/m3.

4.4.2 Strength

Aluminium is strong with a tensile strength of 70 to 700 MPa depending on the alloy and manufacturing process. Extrusions of the right alloy and design are as strong as structural steel.

4.4.3 Elasticity

The Young’s modulus for aluminium is a third that of steel (E = 70,000 MPa). This means that the moment of inertia has to be three times as great for an aluminium extrusion to achievethe same deflection as a steel profile

4.4.4 Formability

Aluminium has a good formability, a characteristic that is used to the full in extruding. Aluminium can also be cast, drawn and milled.

4.4.5 Machining

Aluminium is very easy to machine. Ordinary machining equipment can be used such as saws and drills. Aluminium is also suitable for forming in both the hot and the cold condition.

4.5 Sugarcane Fibre

Bagasse is the fibrous matter that remains after sugarcane or sorghum stalks are crushed to extract their juice. It is dry pulpy residue left after the extraction of juice from sugar cane. Bagasse is used as a biofuel and in the manufacture of pulp and building materials.Agave bagasse is a similar material that consists of the tissue of the blue agave after extraction of the sap.Bagasse can also be very useful to generate electricity. Dry bagasse is burnt to produce steam. The steam is used to rotate turbines to produce power.

#### 4.5.1 PROPERTIES

For every 10 tonnes of sugarcane crushed, a sugar factory produces nearly three tonnes of wet bagasse. Since bagasse is a by-product of the cane sugar industry, the quantity of production in each country is in line with the quantity of sugarcane produced.

The high moisture content of bagasse, typically 40–50 percent, is detrimental to its use as a fuel. In general, bagasse is stored prior to further processing. For electricity production, it is stored under moist conditions, and the mild exothermic process that results from the degradation of residual sugars dries the bagasse pile slightly. For paper and pulp production, it is normally stored wet in order to assist in removal of the short pith fibers, which impede the paper making process, as well as to remove any remaining sugar.

A typical chemical analysis of washed and dried bagasse might show:

Cellulose: 45–55 percent

Hemicellulose: 20–25 percent

Lignin: 18–24 percent

Ash: 1–4 percent Waxes:<1 percent

Bagasse is a heterogeneous material containing around 30-40 percent of "pith" fiber, which is derived from the core of the plant and is mainly parenchyma material, and "bast", "rind", or "stem" fiber, which makes up the balance and is largely derived from sclerenchyma material. These properties make bagasse particularly problematic for paper manufacture and have been the subject of a large body of literature.

### 4.6 MOLD FOR SPECIMEN PREPARATION

The dimension of the particulate fiber reinforced composite boards will be 300 mm (L) x 125 mm (W) and 3 mm thickness. The mold is to be made of steel.

### 4.7 FABRICATION OF COMPOSITE PLATE

The composite plates are to be fabricated using Hand Layup method.

### 4.8 SPECIMEN FOR TESTING

Each composite board are cut into test sample. The cutting processes will be done by using handsaw and other equipment. All specimens are tested based on the standard procedures of ASTM. All other tests are documented.

### 4.9 OVERVIEW OF THE EXPERIMENTAL TESTS

#### 4.9.1 Tensile Test

This test is conducted to determine the tensile properties of the material particularly composites. The prepared tensile specimen are inspected after machining and loaded in the tensile testing machine or universal testing machine and the tensile force is given.

#### 4.9.2 Flexural Test

This test is also called bend test with the suitable fixture subjected to flexural test. The Test is conducted in the universal testing machine in compression mode. The sample is kept on bending fixture and the compressive load is given under specified conditions and the curve is generated till the failure of the sample takes place.

#### 4.9.3 Impact Test

The impact test is the ability of the material to withstand the sudden shock loads.This test is conducted in a Impact testing machine. The machine consists of a loading striker which on releasing possesses fixed kinetic energy. The specimen made would be kept in the machine and the load will be released. The absorbed energy would be indicated in the dial.

### TEST RESULTS

**1. Tensile Test:**

| Test Parameters | Observed Values | | | |
|---|---|---|---|---|
| Sample ID | Glass Fiber With Aluminium Powder & Sugarcane Fiber | | Glass Fiber | |
| | T1 | T2 | T1 | T2 |
| Gauge Width (mm) | 24.03 | 24.04 | 24.77 | 23.90 |
| Gauge Thickness (mm) | 3.51 | 3.01 | 3.04 | 2.97 |
| Original Cross Sectional Area (mm$^2$) | 84.35 | 72.36 | 75.30 | 70.98 |
| Ultimate Tensile Load (kN) | 29.16 | 25.41 | 22.67 | 24.17 |
| Ultimate Tensile Strength (N/mm$^2$ or Mpa) | 346.00 | 351.00 | 301.00 | 341.00 |

**2. Compression Test:**

| Test Parameters | Observed Values | | | |
|---|---|---|---|---|
| Sample ID | Glass Fiber With Aluminium Powder & Sugarcane Fiber | | Glass Fiber | |
| | T1 | T2 | T1 | T2 |
| Gauge Width (mm) | 24.15 | 24.31 | 25.85 | 23.22 |
| Gauge Thickness (mm) | 3.41 | 3.27 | 3.22 | 3.11 |
| Original Cross Sectional Area (mm$^2$) | 82.35 | 79.49 | 83.24 | 72.21 |
| Compression Load (kN) | 1.31 | 1.07 | 1.21 | 0.81 |
| Compression Strength (N/mm$^2$ or Mpa) | 16.00 | 13.00 | 14.00 | 11.00 |

**3. Charpy Impact Test:**

| Test Temperature | Notch Type | Specimen Size (mm) | Sample ID | Absorbed Energy – Joules | | | Average |
|---|---|---|---|---|---|---|---|
| | | | | ID-1 | ID-2 | ID-3 | |
| 24$^0$C | Un Notched | 3 x 12 x 80 | Glass Fiber With Aluminium Powder & Sugarcane Fiber | 12 | 14 | 10 | 12.00 |
| | | | Glass Fiber | 14 | 10 | 18 | 14.00 |

Figure 6.1: Computerized Test results for Tensile, Compression & Impact

## CONCLUSION

From the obtained results we find that the tensile, compressive and impact strength of the glass fiber reinforced with aluminium powder and sugarcane fiber is higher than the glass fiber alone. This will benefit the use of GFRP in various applications like automobile, aeronautical and marine structures.

This result will produce more fusible and dynamic properties in the composite structure. The strength of the glass fiber with aluminium and sugarcane fiber is more than the glass fiber laminate due to their added properties.

The various results indicates us that with the addition of aluminium powder and sugarcane fiber the strength increases rapidly. We took samples consisting of varying composition of aluminium powder and observed the results which indicates that as the composition of aluminum powder increases, the strength also increases rapidly. Addition of sugarcane fiber also provides us the flexural strength which makes the material more durable. The testing done shows us that the glass fibre reinforced with aluminium powder and sugarcane fibre withstands more loads which indicate that the material has high elasticity than glass fibre alone. Also we conclude that, the increase in strength will not have any effect on the actual weight and cost of the laminate since that aluminium is lighter and cheaper along with some added properties of sugarcane fibre which is available naturally makes it more durable and economical.

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