MECHANICAL CHARACTERIZATION OF GLASS FIBRE REINFORCED WITH NATURAL FIBRE

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ABSTRACT: To investigate the mechanical characterization of glass fiber epoxy composite laminates and glass reinforced with natural fiber. To achieve this laminate plate will prepared and then make specimen as per the ASTM standards. This specimen will undergo for testing with data acquisition system. The idea behind the comparison between the GFRP and GFRP reinforced with natural fiber is to evaluate the material property and to find the when & where is used. Mechanical Tests like Tensile, Compression and Impact tests were carried out based on ASTM standard were then conducted to study the effects of interfacial adhesive bonding on impact behavior of these laminates.

Keywords: composites, glass fibre reinforced plastic, natural fibre, tensile testing, compression testing, impact testing

1 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.

The most commonly used advanced composites are polymer matrix composites. These composites consists 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.

The building block of a laminate is a single lamina. Therefore the mechanical analysis of a lamina precedes that of a laminate. A lamina is an anisotropic and non-homogeneous material. But for approximate macro-mechanical analysis, a lamina is assumed to be homogeneous where the calculation of the average properties are based on individual mechanical properties of fiber and matrix, as well as content, packing geometry and shape of fibers. The lamina is considered as orthotropic, so it can be characterized by nine independent elastic constants: three Young’s moduli along each material axis, three Poisson’s ratio for each plane and three shear moduli for each plane. Once the properties for each lamina are obtained, properties of a laminate, made of those laminate can be calculated using those individual properties.

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.

2. Literature Review

The purpose of this literature review is to provide background information on the issues to be considered in this thesis and to emphasize the relevance of the present study. This treatise embraces some related aspects of polymer composites with special reference to their mechanical property.

2.1 An experimental investigation on the bearing failure load of glass fiber/epoxy laminates

Francesco Ascione, This paper deals with an experimental investigation on the bearing failure load of glass fiber/epoxy (GFRP) laminates. The effects of fiber-to-load inclination angle and laminate stacking sequence on the bearing load capacity have been determined experimentally on two different type of laminates: unidirectional and bi-directional (cross-ply). Significant reductions in bearing failure load when fibreinclination angle increases are highlighted. Bearing design formulas are also proposed based on the results of the experiments.

2.2 Modeling of the low-impulse blast behavior of fiber-metal laminates based on different natural fiber alloys

Thuc P. VO, A parametric study has been undertaken in order to investigate the influence of the properties of the natural fiber alloy on the blast response of fiber-metal laminates (FMLs). The finite element (FE) models have been developed and validated using experimental data from tests on FMLs based on a 2024-O natural fiber alloy and a woven glass–fiber/polypropylene composite (GFPP). A vectorized user material subroutine (VUMAT) was employed to define Haskin’s 3D rate-
dependant damage constitutive model of the GFPP. Using the validated models, a parametric study has been carried out to investigate the blast resistance of FML panels based on the four natural fiber alloys, namely 2024-O, 2024-T3, 6061-T6 and 7075-T6. It has been shown that there is an approximation linear relationship between the dimensionless back face displacement and the dimensionless impulse for all natural fiber alloys investigated here. It has also shown that the residual displacement of back surface of the FML panels and the internal deboning are dependent on the yield strength of the natural fiber alloy.

2.3 Coefficient of friction for Natural fiber in contact with a carbon fiber epoxy composite

Joakim Schön, in bolted joints, a large part of the load is transferred by friction. The objective of this investigation is to measure the coefficient of friction for carbon fiber epoxy matrix composite, HTA-6376 and removed from the surface. Pieces of carbon fiber caused depressions in the natural fiber surface. The wear debris is reattached to the composite surface but not to the natural fiber surface. , in contact with natural fiber, 3637-77, in reciprocal sliding. During testing, the coefficient of friction increased initially with number of cycles and after reaching a maximum, slowly decreased. The initial coefficient of friction is approximately 0.23 and the peak coefficient of friction after wear in is approximately 0.68. The coefficient of friction is independent of normal load. During wear, cracks are formed at the fiber–matrix interface, which causes the matrix layer on the original composite surface to break off in pieces. It also causes single fibers or groups of fibers to be broken off.

2.4 Bearing strength of commingled boron/glass fiber reinforced natural fiber laminates

Po-Change, The bearing properties of recently developed hybrid fiber/metal laminates, or Commingled Boron/glass fiber Reinforced Natural fiber laminates (COBRA), are investigated in this study. The bolt-type bearing tests on Glass Reinforced natural fiber laminates (GLARE), non-commingled hybrid boron/glass/natural fiber fiber/metal laminates (HFML) and COBRA were carried out as a function of e/D ratio, metal volume fraction, fiber volume fraction, and fiber orientation. Experimental results show that with the same joint geometry and metal volume fraction, the commingling of boron fibers improves the bearing strength of fiber/metal laminates. Observations show the boron/glass fiber prepares transverse to the loading direction, results in a bearing mechanism that effectively increases the bearing strength. The bearing strength of COBRA with longitudinal fibers is lower than that with transverse fibers due to the
fact that shear out failure takes place before maximum bearing strength is reached. The experimental results show that, with only either transverse fiber orientation or longitudinal fiber orientation, COBRA with 18% boron fiber volume fraction possesses a higher bearing strength when compared to HFML with 6% boron fiber volume fraction. In addition to the properties in COBRA with parallel-ply commingled prepare, the bearing properties of various COBRA with [0°/90°] and [0°/90°/90°/0°] cross-ply commingled prepress are also discussed.

2.5 Experimental comparison of the dynamic performance for steel, natural fiber and glass-fiber-reinforced-polymer light poles

Luca Caracole, This study is conceived as the second part of an experimental analysis and focused on the performance of tapered highway light poles under dynamic excitation. The original motivation coincides with a forensic investigation for the definition of the most plausible collapse cause for natural fiber-alloy highway light poles during a wind and winter storm. The comparison of the performances is based on frequency and damping ratios corresponding to first- and second-mode vibration. Experimental testing is employed to derive the dynamic characteristics of the units; moreover, the behavior of a damping device, previously proposed for mitigation of vulnerable units, is analyzed. Previous results, derived for a limited set of cases, are extended in this study to other configurations, including different materials and geometry. Discussion on the derivation of frequency and damping in the presence of closely spaced modes, typical of these systems, is provided. In particular, the effectiveness of several methods for the identification of such quantities is carefully compared.

3. Materials and methodology

- **GFRP LAMINATE**
- **In this laminate,**
- **REINFORCEMENT- Glass Fiber Reinforcement Plastic**
- **E-glass.**
- **MATRIX- Epoxy.**
- Correct ratio of resin and hardener is 10:1
- Resin : LY556  Hardener : HY951

### 3.1 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.

### 3.2 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.

### 3.3 Banana Fiber

Appearance of banana fiber is similar to that of bamboo fiber and ramie fiber, but its fineness and spinnability is better than the two. The chemical composition of banana fiber is cellulose, hemicelluloses, and lignin. It is highly strong fiber. It has smaller elongation. It has somewhat shiny appearance depending upon the extraction & spinning process. It is light weight. It has strong moisture absorption quality. It absorbs as well as releases moisture very fast. It is bio-degradable and has no negative effect on environment and thus can be categorized as eco-friendly fiber. Its average fineness is 2400Nm. It can be spun through almost all the methods of spinning including ring spinning, open-end spinning, bast fiber spinning, and semi-worsted spinning among others.

### 3.4 Method: Hand Lay-Up

Even though the method has been replaced with automated techniques, the lay-up of pre-impregnated material by hand is the oldest and most common
fabrication method for advanced composite structures. Furthermore, the basic features of the method remain unchanged. Each step must follow in successive fashion in order to obtain a high-quality composite laminate after final processing. A description of these steps follows.

Step 1
The surface of the tool is cleaned and a release agent is applied. If the surface is not clean, then the release agent will not function properly. The release agent can be in liquid form, or it may be a solid film. (In the photo-essay, to provide an indication of scale, a hand-held pointer or knife is included in the photographs.)

Step 2
An optional sacrificial layer is laid up on the tool surface. This layer is usually a fiberglass fabric made with the same resin system as the composite laminate. The sacrificial layer protects the laminate from surface abrasion and surface irregularities during manufacturing.

Step 3
A peel ply is placed on top of the sacrificial layer. The peel ply will be removed after processing.

Step 4
The pre-impregnated plies are cut according to design specifications. They can be cut by hand using shears or a steel blade knife. However, automated cutting machines have largely replaced hand cutting. The Gerber knife is a reciprocating-knife system originally developed for the textile industry. It is extremely fast and can cut up to 20 plies at one time. Lasers have been used for cutting, but they are expensive and have limitations on the number of plies that can be cut at one time. Water-jet cutters are also used extensively, and they can cut a large number of plies (> 40) at one time, but some moisture absorption occurs during the cutting operation. Ultrasonic cutters have been used as well.

Step 5
The first prepare ply is oriented and placed upon the tool or mold. Subsequent plies are placed one upon another; a roller or other small hand tool is used to compact the plies and remove entrapped air that could later lead to voids or layer separations. It is important that the pre-impregnated material have sufficient tack so that it sticks slightly to the peel ply and to the adjacent plies. Tackiness, a characteristic of pre-impregnated material, quantifies the relative stickiness of the plies at room temperature. As the pre-impregnated material ages, its tackiness is reduced. Eventually, the plies no longer stick together and they may have to be heated slightly to soften them during lay-up. Oils and dirt on the surface of the pre-impregnated plies will contribute to reducing composite strength after processing. Technicians should wear gloves during lay-up so that oils and dirt from the hands do not contaminate the prepare plies during lay-up. In some cases the hand lay-up procedure may be carried out in a clean room to reduce the risk of contamination of the prepare plies.

Step 6
A flexible resin dam is anchored to the sacrificial layer approximately 3 mm from the edge of the laminate. The dam prevents resin flow out of the laminate, in the plane of the laminate. Flexible dams can be made from silicon rubber, cork, or release coated metal. (As no sacrificial layer is being used in the procedure here, the flexible dam is anchored to the peel ply).

Step 7
Another peel ply is placed on top of the laminate to protect the laminate surface.

Step 8
A sheet of porous release film is laid over the dam and the laminate. The porous release film will serve as a barrier to prevent bonding of the composite laminate to the secondary materials to follow.

Step 9
Next, bleeder plies are laid up over the release film, in this case the peel ply. The bleeder plies extend to the edge of the laminate. The number of bleeder plies to be used for a given laminate can be determined by using a resin flow process model or through empirical observation. As the number of bleeder plies increases, the
final fiber volume fraction of the composite laminate increases. Eventually, a maximum number of bleeder plies is reached and no further increase in fiber volume fraction occurs.

Step 10
Another porous release ply is next laid up over the bleeder plies extending past the flexible dam. This prevents excessive resin flow into the breather material while maintaining a vacuum pathway into the composite laminate.

Step 11
Breather plies are placed over the entire lay-up. The breather plies will conduct the vacuum path into the laminate. It is critically important that sufficient breather material is used throughout the entire laminate. Creases and areas with shallow curvature are sometimes reinforced with additional layers of breather material to ensure that the breather plies do not collapse in these areas. Usually, two or three breather plies are sufficient.

Step 12
An edge bleeder is used to connect to the vacuum ports. An edge bleeder is nothing more than a strip of breather material folded along its length several times. It is placed so that it overlays the breather material surrounding the laminate and extends out to a convenient location for the placement of the vacuum port.

Step 13
Caul plates are sometimes placed on top of the lay-up. The caul plate is steel or natural fiber plate that protects the surface from sharp temperature increases (it acts as a heat sink) and it gives a smooth non-wavy surface texture.

Step 14
If a caul plate is used, then additional breather or bleeder plies are placed over the plate to protect the vacuum bag from puncture.

Step 15
Sealant tape is placed around the entire periphery of the lay-up.

Step 16
The vacuum bag is cut to size and placed over the lay-up.

Step 17
The bag is sealed by pressing the bag over the sealant tape. It is critically important to ensure that the bag is adequately sealed before proceeding to the processing cycle. Many parts are scrapped because the vacuum fails during processing, causing excessive voids, inadequate resin flow, or incomplete consolidation.
The vacuum port is installed through the bag and the contents are evacuated. The bag is now checked for leaks. If any are detected, they are repaired before processing. Usually a leak test calls for application of a vacuum to some specified level (cm of Hg), followed by a 30-60 minute hold. During the hold the bag is disconnected from the vacuum source and the pressure level within the bag is monitored. If the bag is sealed well and there are no leaks, then the vacuum level should not change for the 30-60 minutes. Some leaking generally occurs, so it is a question of having sufficient vacuum pump capacity to maintain the specified vacuum level. When the vacuum is satisfactory, the composite part is ready for processing. The specific processing steps depend on the particular composite material being used, and the operation of the autoclave depends on the specific make and model. General discussions of processing and autoclave features are presented in the sections to follow. Obviously, there is a significant amount of skilled labor necessary for the hand lay-up of composite parts. Each step has a specific purpose and function. This type of fabrication is the most time-consuming, but it is also the most flexible and when combined with autoclave processing, it results in high-quality parts.

4. Test Results

4.1. Tensile Test

<table>
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<th>Test Parameters</th>
<th>Observed Values</th>
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<td>Sample ID</td>
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<td>Glass Fibre</td>
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<tr>
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<td>Gauge Thickness (mm)</td>
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4.2. Compression TEST

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<tr>
<td>Gauge Width (mm)</td>
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C. CHARPY IMPACT TEST

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<td>13 17</td>
<td>13.00</td>
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5. Conclusion

From the obtained result we find that the tensile and impact strength of the glass fiber with natural fiber is higher than the glass fiber alone. This will effect in the application like automobile, aeronautical and marine structures. This result will produce the more fusible and dynamic properties in the composite structure. The strength of the glass fiber with aluminum and natural fiber is more than the glass fiber laminate due to the added properties of them.

The flexural strength of glass fiber will not be increased during the reinforcement of al with glass fiber, but testing the glass fiber with natural fiber, the specimen was not broken which cause the bending only so that the elastic property will be high when compared to that of glass fiber 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 Aluminum is lighter and cheaper along with some added properties of sugarcane fiber.

References