AAAFM MATERIALS

ORIGINAL ARTICLE

Advantages and Disadvantages of Using Composite Laminates in Industries

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ABSTRACT: With today's growing interest toward composite materials and their augmentation as part of integrated business from aerospace engineering, medical applications and others are getting more and more dependent on composite materials in recent operations. However, the most sophisticated composite materials still need to rely on the other integrated sub-sets of components. On the other hand, there are certain limitations and flaws that exist within composite materials' component that can cause an error to grow way beyond control and can impact its main master component. These sorts of limitation and flaws would also impact the engineering targets from the perspective of resilience built into the daily operations that are also pointed out in the current article.

KEYWORDS: Composite material, Laminate, Carbon nanotubes, Carbon fiber-reinforced composites (CFRP).

INTRODUCTION

The composite materials are produced when two or more different materials are laminated together. These laminae were found to have numerous uses due their high strength to weight ratio and resistance to corrosion and surface degradation. Figure 1 briefly explains the composition of a composite material [1].

Optimizing the construction of composites, multiple adjusted layers (laminae) are used to form a laminate. Figure 2 shows the layers of individual laminates having different fiber directions combined to form a laminate. By changing the direction of the fibers in the resin, the material properties can be tailored to fit the required properties in a structure [2].

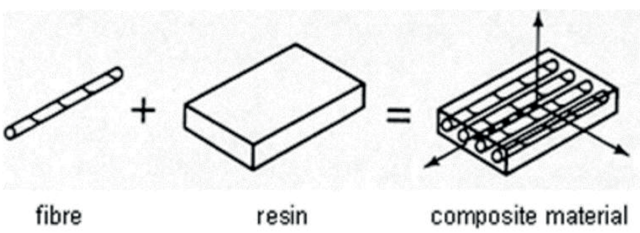

Figure 1. Composition of a composite material.

The fiber reinforcement plays a major role in determining the structural properties in a composite material. Since the fiber is held together with the matrix resin, it optimizes the properties in the final part such as strength and stiffness, while still minimizing the weight [2-5]. The primary function of the fibers is to carry the loads along their longitudinal directions [6]. Common fiber-reinforcing agents include:

i. Carbon (Graphite);
ii. Glass (E-glass, S-glass, D-glass);
iii. Polyamide (aromatic polyamide, aramid), e.g., Kevlar 29;
iv. Quartz (fused silica);
v. Titanium.

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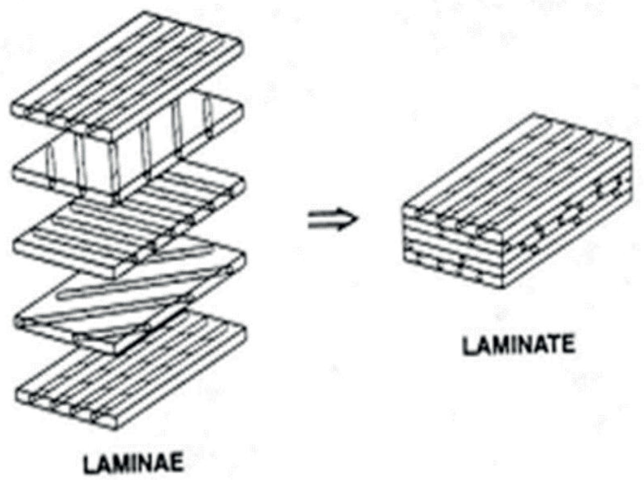

Figure 2. Tailored composites.

Table 1. Advantages and disadvantages of composites.

Benefits	Drawbacks
High-impact damage resistance.	Composites are more brittle than wrought metals, making them much easier damaged.
Resistant to fatigue and corrosion degradation.	Matrix is susceptible to environmental degradation.
High strength-to-weight ratio.	Transverse properties may be weak.
The fiber pattern can be tailored to efficiently sustain the applied loads. These directional tailoring capabilities allow products to meet the design requirements.	Costs of raw materials and fabrication are expensive.

Resins show a wide variation in properties and they are relatively low cost. Due to this, most composite matrices are made of resins. Aside from protecting the fibers from mechanical and/or environmental damages, the matrix also serves to transfer stresses between the reinforcing fibers [7]. Common resin material includes:

i. Epoxy;
ii. Phenolic;
iii. Polyester;
iv. Polyurethane;
v. Vinyl Ester.

BENEFITS AND DRAWBACKS OF USING COMPOSITES

Polyesters are the most widely used resin systems. Epoxies come in second for their higher cost, with advantages of having higher adhesion and less shrinkage than polyesters. Using composites has their own pros and cons. Depending on their purposes, trade-offs should be considered when implementing composites in a design. Table 1 summarizes the advantages and disadvantages of composites [8].

Composites are incorporated in many fields. This includes from household items to construction parts. Several household items which incorporate composites are window frames, bath tubs, and doors [16]. Sporting goods such as rackets and bicycles also implement the use of carbon nanotubes and carbon fiber-reinforced composites (CFRP), respectively. In public infrastructures, several bridges and utility poles use composites in its construction. Among the composites implemented are carbon composites and glass composites [9].

Due to its high strength-to-weight ratio, composites are highly demanded in the aerospace industry. Weight is a critical parameter in aerospace. It affects the flying capabilities of an aircraft. Previously, aircraft structures consisted only of metal, which resulted in a heavy overall structure [10].

When composites were introduced, they were found to be able to significantly reduce the weight of the aircraft while providing comparable or even higher structural integrity than that of metals at the same time [11].

Nowadays, more and more aircrafts are incorporating composites in its design to make it lighter. A lighter aircraft also means less fuel consumption and, therefore, allows lower emission of greenhouse gasses. Among commercial aircrafts which incorporate composites in its design are the Airbus A380 and Boeing 787 Dreamliner. The A380 contains about 25-30 tons of composites, 85% of which is CFRP. On the other hand, 50% of the B787 Dreamliner comprises composites, with the remainder being 20% aluminum and 30% titanium. Figures 4 and 5 show the composition of composites implemented in the aircrafts, respectively [12].

Fiber-reinforced composite materials have various functions in most industries, especially the aerospace industry, due to the high specific stiffness. Nonetheless, the expense of conventional composites is also notable. Ordinarily, haphazard divided fiber-reinforced composite materials appeared as affirming the most outstanding alternative materials for unique manufacturing challenges, joining the methods, and the basic material selection considerations for multi-material lightweight structures due to the mass production capabilities and low cost [13]. For instance, the possible use in the automotive industry was recorded. In contemplation of expanding the application, meticulous material characterization is needed. Subsequently, the major complication in the quite exploring models of the geometry at the micro-level of 35%-40% fiber volume ratios is even more expressed at the highest aspect ratio among the different types of reinforcements [14].

Glass-fiber-reinforced composite materials have shown limited applications in terms of construction and building industry for several years. Recently, good potential for the applications of fiber-reinforced composite materials for numerous applications due to expeditiously retrofit and repair deteriorating infrastructure is being achieved [15]. Moreover, the mechanical properties of fiber-reinforced composite materials closely depend on the properties of the component materials, such as void content, type, orientation, fiber distribution, and quantity. On the other hand, the main concept of the interfacial bonds and the mechanism of load transfer at inter laminar also play vital roles [16]. Accordingly, varied researchers discuss about

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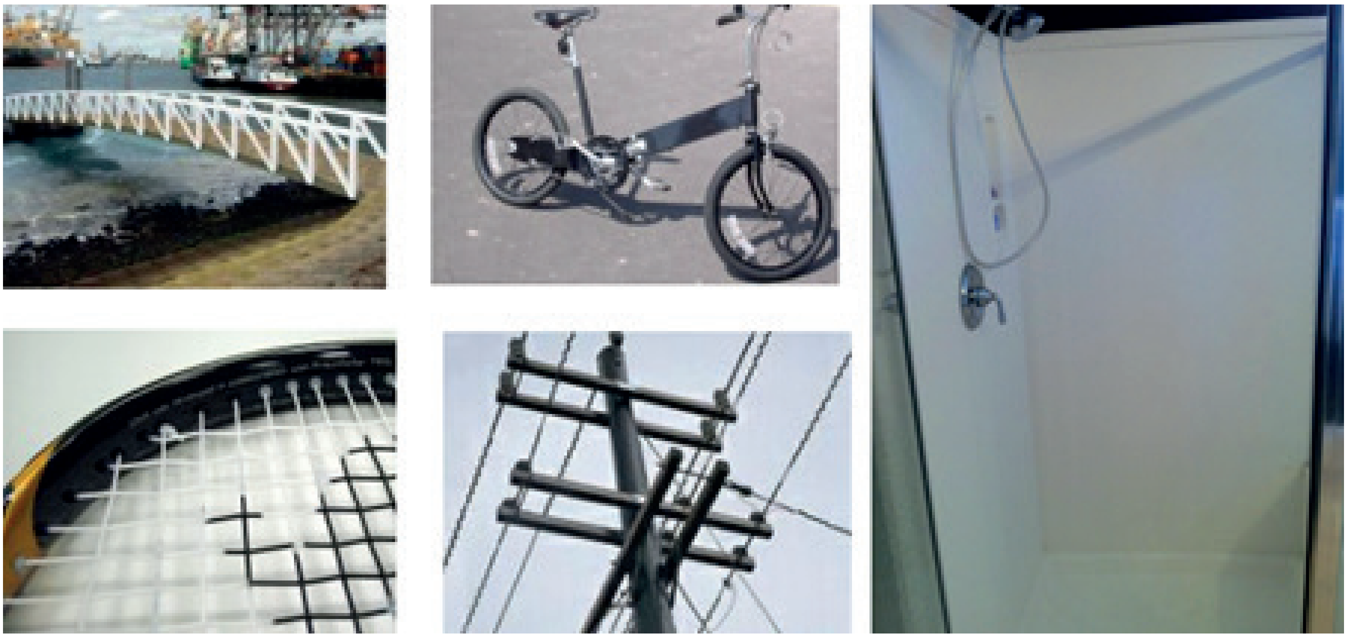

Figure 3. Application of composites in daily life.

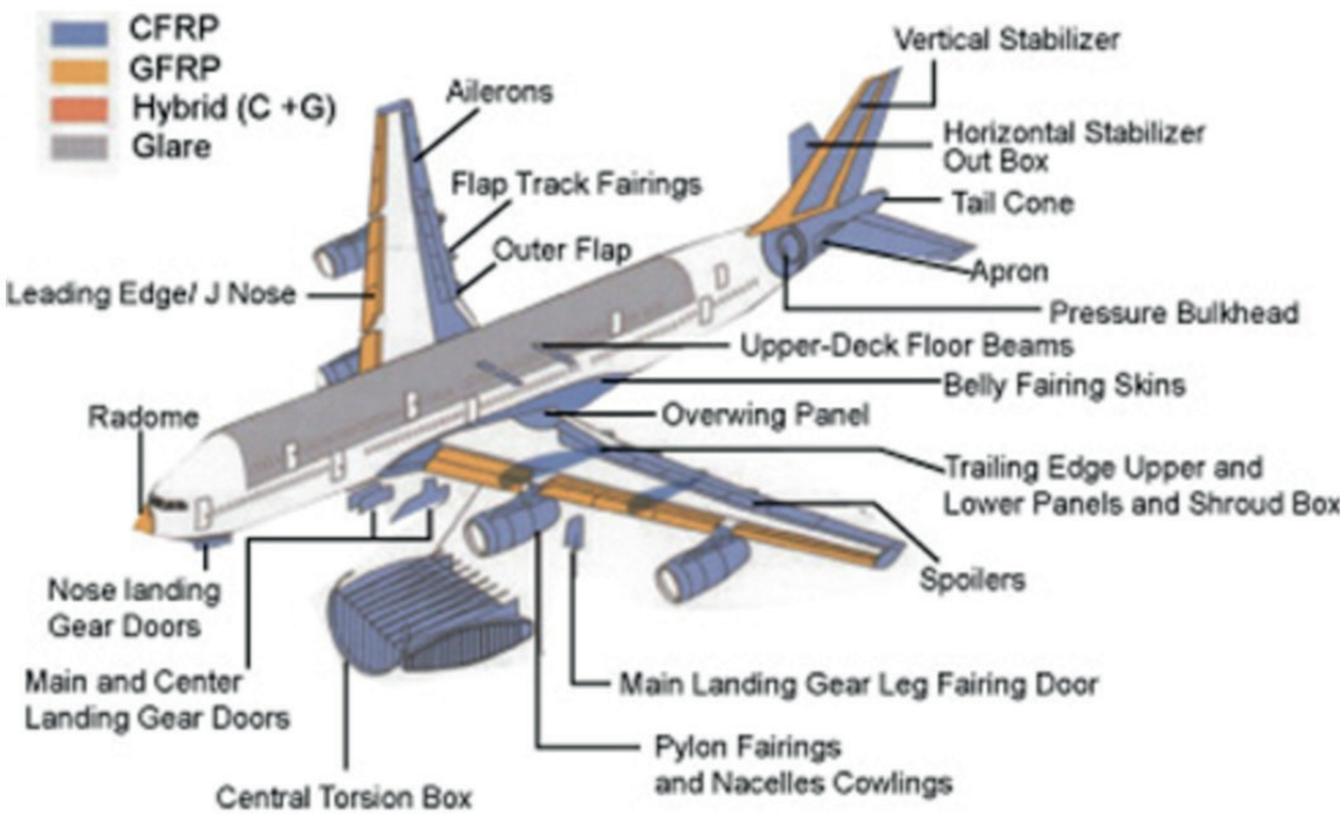

Figure 4. Composition of composites in A380.

the design process of short-fibers reinforced composite materials. Therefore, they are ready for use, with attention paid to the strength properties of the composite materials that reported the effects of them on shapes of the fibers in short-fibers glass composite materials [15-18]. The flexural strength and vertical stress generated by bending moment of avoided short-fibers reinforced composites were studied by considering the effects of fiber orientation and length on mechanical properties. In addition, recently, efforts to reduce the weight of automobiles by the increased use of plastics and their composites have led to a growing penetration of short-fiber reinforced injection molding thermo-

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Figure 5. Composition of composites in B787 Dreamliner.

plastics into fatigue-sensitive applications [16-19]. Mainly, short-fiber–resin matrix composite materials are minor fatigue resistance than the correspondingly continuous fiber-reinforced composites, which are extensively applied in the piping and pipeline systems and the pressure vessels for all major chemical industries [17-21].

SUMMARY

The flexural strength and vertical stress generated by the bending moment of avoided short-fibers reinforced composites were studied by considering the effects of fiber orientation and length on mechanical properties. In addition, recently, efforts to reduce the weight of automobiles by the increased use of plastics and their composites have led to a growing penetration of short-fiber reinforced injection molding thermoplastics into fatigue-sensitive applications. Mainly, short-fiber–resin matrix composite materials are minor fatigue resistance than the correspondingly continuous fiber-reinforced composites, which are extensively applied in the piping and pipeline systems and the pressure vessels for all major chemical industries.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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