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Title

Mechanical characterization and damage mechanism of a new flax-Kevlar hybrid/epoxy composite

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Abstract

A new composite, made with a woven constituted by Kevlar fibers and flax fibers in an epoxy resin is tested. Tensile and three-point bending tests are performed to identify mechanical properties and damage mechanisms. Compressive properties are identified by an inverse method using numerical simulation of the bending test. In addition, failure mechanisms are established by macroscopic and microscopic observations. The composite exhibits a strong non-linear anisotropic behavior. This non-linearity comes from the plastic strain of Kevlar fibers and flax fibers pull out, whereas the damaged modulus depends on the flax fibers damage. The hybrid composite has the same compression weakness as Kevlar composite, with compression properties that are lower than the tensile properties. Hybrid composite has an intermediate mechanical property between flax composite and aramid composite.

Keywords

A. Hybrid composite, A. natural fiber, C. Damage mechanics, D. Mechanical testing

1 Introduction

An important target for the industry is to reduce its carbon footprint. One way to save energy is to replace glass fibers with natural fibers such as flax [1]. Flax fibers are the subject of many recent papers because of their specific mechanical properties, which are similar to glass fibers with a low energy production. Moreover the flax capability to increase the damping properties of a laminate is well known and could be interesting for increasing damage tolerance [2], [3], [4]. However, its hydroscopic sensitivity and fire resistant weakness make it difficult to use as a structural part in industry [5]. In order to improve the mechanical properties and moisture resistance of natural composites, some authors study hybrid composites using natural fibers in combination with synthetic fibers. In the study of hybrid composites, it is necessary to distinguish the intraply hybridization from the interply one. The interply hybridization consists in coupling layers of different materials. The intraply hybridization consists in coupling different fibers within the same ply. The effects of these two technologies have been summarized in a synthesis study [6]. Material dispersion appears to be the most important parameter in hybridization and has been confirmed by many authors. For example, *Pegoretti et al.* [7] demonstrate that intraply hybrid composites have better resistance to crack propagation at impact. They conclude that a better mix of properties conducts to a limitation of residual stresses that can occur between two plies with different properties.

The hybridization technology applied to natural fiber has demonstrated several improvements in mechanical properties and durability, such as reduced variability of properties and reduced sensitivity to moisture. Thus, *Salman et al.* [8] have identified a high fatigue resistance behaviour of a Kenaf/ hybrid Kevlar

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