



**HAL**  
open science

# FLAX FIBRE COMPOSITE FOR VIBRATION DAMPING DESIGN

Thuy Quynh Truong Hoang, Zouhaier Jendli, Abderrahim El Mahi

► **To cite this version:**

Thuy Quynh Truong Hoang, Zouhaier Jendli, Abderrahim El Mahi. FLAX FIBRE COMPOSITE FOR VIBRATION DAMPING DESIGN. Special JEC World (111) TECHNOLOGY Natural Fibres., 2017, pp.114-115. hal-04943406

**HAL Id: hal-04943406**

**<https://hal.science/hal-04943406v1>**

Submitted on 12 Feb 2025

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0  
International License

# FLAX FIBRE COMPOSITE FOR VIBRATION DAMPING DESIGN

Thuy-Quynh.Truong-Hoang, *Lecturer,*

Zouhaier Jendli, *Associated Pr., ESTACA - Campus Ouest Parc Universitaire Laval,*

Abderahim El Mahi, *Professor, Université du Maine – LAUM Laboratory.*

**Natural fibres, especially flax, are already known for their damping properties due to their specific structure. ESTACA and the LAUM laboratory compared the behaviour of flax and glass fibres embedded in a thermoplastic acrylic resin for infusion moulding.**

In recent times, the transport industry has focused on lightweight materials with good mechanical properties and lower environmental impact. Glass fibre-reinforced composites have good mechanical properties and are widely used in many application areas. However, the manufacture of glass fibres and their end-of-life disposal remain a major environmental problem. Natural fibres have a lower environmental impact and offer high specific mechanical properties as well as sound absorption and vibration damping properties. Vibration and damping issues have become increasingly important over the past decades since vibrations are undesirable in structures that need to combine performance, durability, and noise reduction. One of the alternative solutions to reduce vibration disturbances is to use natural fibres for the reinforcement of composite structures.

In the work described in this paper, flax fibre-reinforced thermoplastic composites were characterized in terms of vibration behaviour and compared with glass fibre-reinforced thermoplastic composites. The purpose was to characterize the damping properties of these two composite materials in order to propose new solutions to reduce structural vibrations.

Elium™ is an innovative liquid acrylic thermoplastic resin produced by Arkema that can be processed with techniques conventionally used for thermosetting resins. The flax and glass fibres used were  $\pm 45^\circ$  bidirectional superimposed fabrics supplied by Terre de lin and Saertex. Their average fibre weight was respectively 400g/m<sup>2</sup> for the flax fibre fabric and 440g/m<sup>2</sup> for the glass fibre fabric.

## I. Experimental measurements

### I-1 Composite processing

Vacuum-assisted resin transfer moulding was used to produce the composite plates. This liquid composite moulding process has been widely used to manufacture thermosetting composites. Before processing, the flax fibre preforms were dried in an oven at 110°C during 5 hours. Then, the preforms were sealed using a flexible vacuum bag. The composite plates were made of two layers of flax or four layers of glass in order to obtain an equivalent nominal thickness value. After processing, the fibre volume fraction was determined for both composites: 40% for the flax fibre composite and 44% in the case of the glass fibre composite.

### I-2 Damping measurements

The experimental equipment used is represented in Figure 1. A fixed-geometry beam was clamped at the end of a fixed support. A force hammer was used to impact the point close to the clamped side. A laser Doppler vibrometer measured the velocity of the free end of the beam. Then, the signals were processed by a laboratory software using the circle fitting method to determine damping as a function of the vibration frequency. By definition, the modal damping loss factor  $\eta$  relates to the damping ratio  $\zeta$  by the relation  $\eta=2\zeta$ . In order to compare the damping loss factor between different materials, the specific loss factor was defined by dividing the damping loss factor by the composite density ( $d_c$ ).

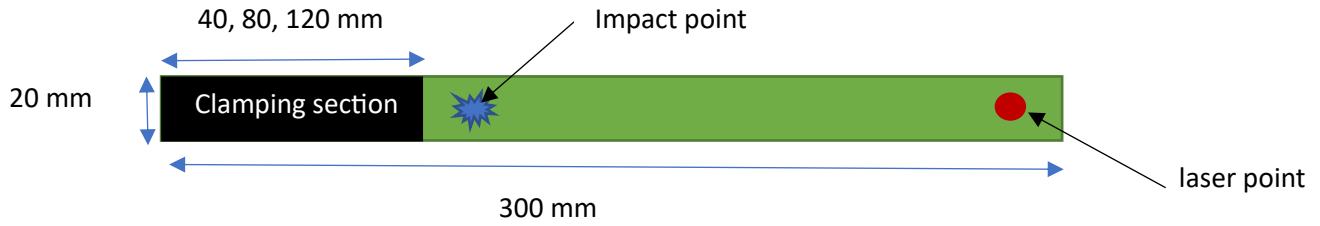


Figure 1: Geometry for the vibration beam testing samples.

## II. Characterization of damping properties

The specific loss factor results are shown in Figure 2a both for the composites in the 0° fibre direction and for the polymerized Elium™ resin as a function of the frequency. The Elium™ resin shows the highest damping factor compared to the composites and its value decreases rapidly at higher frequency. This result is linked to the viscoelastic behaviour of the thermoplastic resin. Indeed, at a higher vibration frequency, less time is available for the damping mechanisms to occur, resulting in lower damping. On the contrary, the composite damping responses show similar damping profiles and seem to be constant as a function of frequency. However, the specific damping loss factor for the flax fibre composite is twice as high as the factor for the glass fibre composite. The results can be explained by the intrinsic multi-scale hierarchical nature of flax fibre, which contributes to friction mechanisms such as intra- and inter-cell wall friction and hence dissipates vibration energy.

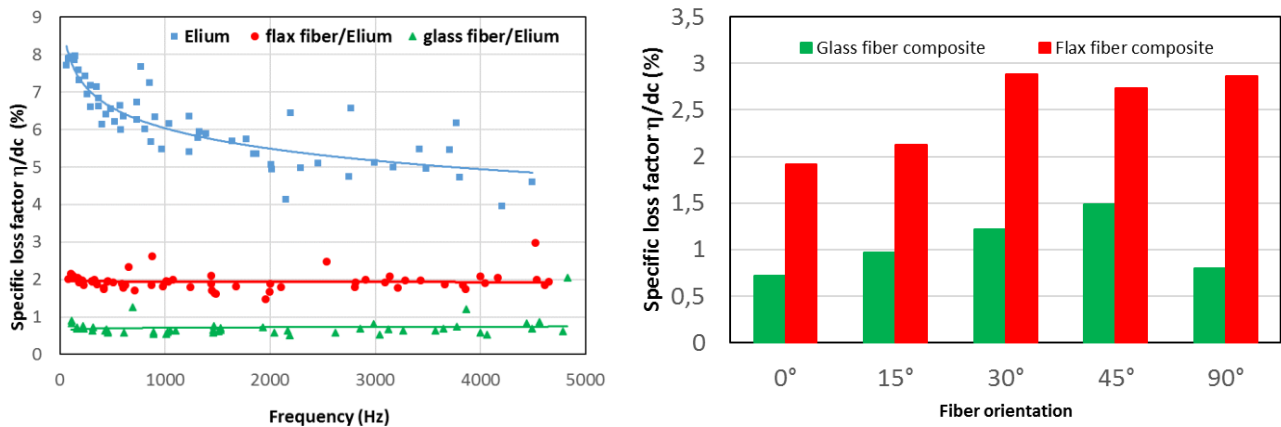


Figure 2: (a) Damping properties versus frequency; (b) Evolution of the specific loss factor with fibre orientation.

The effect of fibre orientation on the vibration properties is presented in Figure 2 (b). The specific loss factor was found to increase with fibre orientation and reach the maximum value at 45° in the case of the glass fibre composite and 30° in the case of the flax fibre composite. By changing the fibre orientation, it is possible to create a composite laminate with a superior damping factor. An analytical model used to predict the damping loss factor of the fibre in the composite is shown in Equation 1:

$$\eta_c = \frac{V_f}{V_f + \frac{E_r}{E_f}(1-V_f)} \eta_f + \frac{1-V_f}{(1-V_f) + \frac{E_f}{E_r}V_f} \eta_r \quad \text{Equation (1)}$$

Where  $\eta_f$ ,  $\eta_r$ ,  $\eta_c$  are the damping loss factors of the fibre, resin and composite,  $V_f$  is the fibre volume fraction, and  $E_f$ ,  $E_r$  are respectively the fibre and resin Young's modulus.

Using this equation, the fibre damping factors found are about 2.1% and 1.0% for flax fibre and glass fibre respectively. Flax fibres exhibit better damping properties than glass fibres.

### III. Conclusion

Natural fibre-reinforced thermoplastic composites using Elium™ resin were compared with glass fibre composites. The vibration absorption measurements highlighted the higher functional capability, in terms of damping, of flax fibres versus glass fibres. By combining flax fibres with thermoplastic resins, it is possible to design a green composite that meets both the low weight and vibration comfort requirements of the transport industry. The authors are grateful to the FiMaLin association for its financial support to this study.

More information: [www.estaca.fr](http://www.estaca.fr) ; <http://laum.univ-lemans.fr>

Contact:

[thuy-quynh.truong-hoang@estaca.fr](mailto:thuy-quynh.truong-hoang@estaca.fr)

[Zouhaier.jendli@estaca.fr](mailto:Zouhaier.jendli@estaca.fr)

[abderrahim.elmahi@univ-lemans.fr](mailto:abderrahim.elmahi@univ-lemans.fr)

#### About ESTACA and the LAUM laboratory

ESTACA is an engineering school specialized in transportation and a member of the ISAE group and the FiMaLin association. The Mechanics department of ESTACA'LAB is involved in developing advanced multifunctional composite materials for smart structure applications in transport.

LAUM is a Coeducational Research unit of the Université du Maine (UM) at Le Mans and of the CNRS (Centre National de Recherche Scientifique) as the UMR 6613.

The research activities of the lab are performed as part of three teams specialized on complementary themes: Acoustics and Mechanics of materials, Transducers, Vibrations, Guided Acoustics and Flow.

#### ” Citation

Thuy-Quynh.Truong-hoang, Zouhaier Jendli, Abderrahim El Mahi. Flax fibre composite for vibration damping design. JEC Composites Magazine 03/2017 ; Special JEC World (111) TECHNOLOGY Natural Fibres : 114-115.

Publisher: JEC Composites Magazine. <https://digital-magazine.jecomposites.com/jec-composites-magazine/jec-composites-magazine/n111-2017>