SSUCHY
DEVELOPING ADVANCED BIO-BASED COMPOSITES

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DAMPING PROPERTIES OF BIO-BASED COMPOSITES

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BBI JU
Bio-based Industries Consortium
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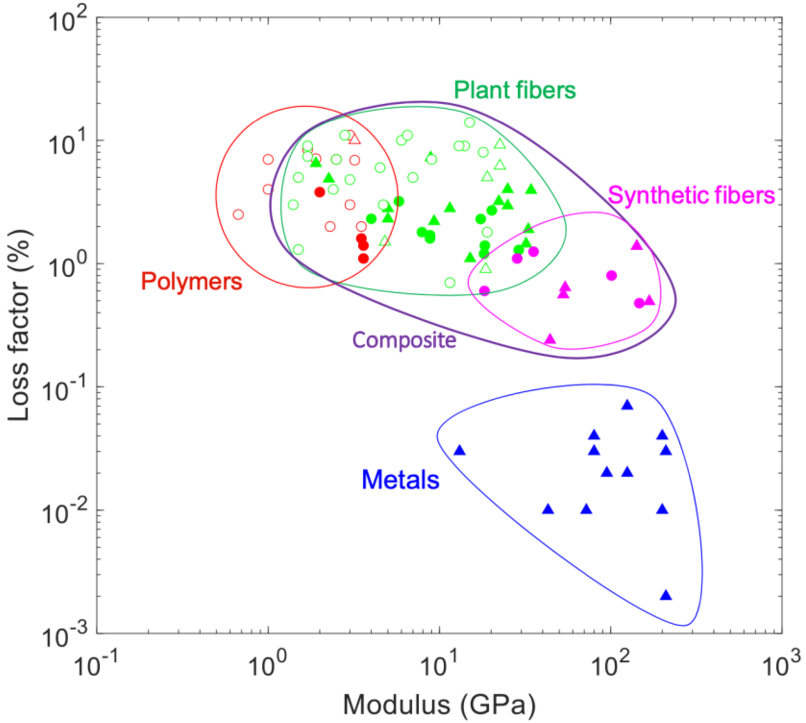
Final Event *– Videoconference – 9th February 2022*

DAMPING CAPABILITIES OF BIO-BASED COMPOSITES

Bibliography analysis: bio-based composites exhibit high damping capabilities

Elastic modulus (stiffness) vs. Loss factor (damping capability)



Liu, T., Butaud, P., Placet, V., & Ouisse, M. (2021). Damping behavior of plant fiber composites: a review. Composite Structures, 275, 114392.

=> Promising properties for a wide variety of applications where vibration/acoustic levels should remain low (transportation, industry, leisure, …)

Questions addressed during SSUCHY project:

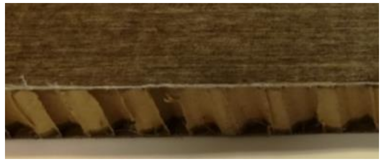
What are the **physical explanations** of these properties?
What are the **environemental parameters** that may affect these properties?
How can we **design bio-based composite structures** with tailored damping properties?
Can we take advantage and use these properties for **industrial applications**?

Materials considered during SSUCHY project:

Various skins: flax, hemp fibers, UD or woven, with epoxy or polyamide resins
Various cores: paper honeycomb, balsa, cork, recycled PET foam
both **from the market** or **developed in the project**

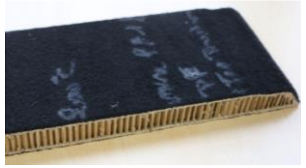
Flax/Epoxy skins with Balsa Core

Flax/Epoxy skins with rPET Foam Core



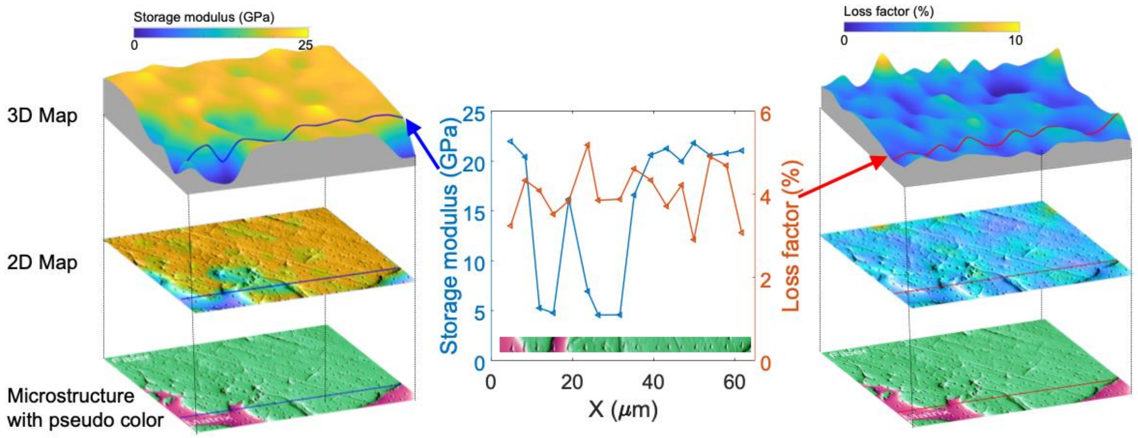
Flax/Epoxy skins with Paper Honeycomb Core

Flax/Epoxy skins with Lightened Balsa Honeycomb Core



Hemp/Polyamide skins with Paper Honeycomb Core

Micro analysis of composite skins using nano-indentation

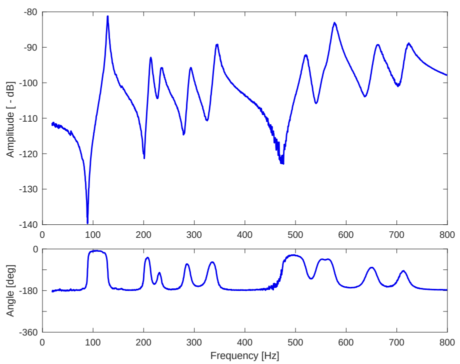


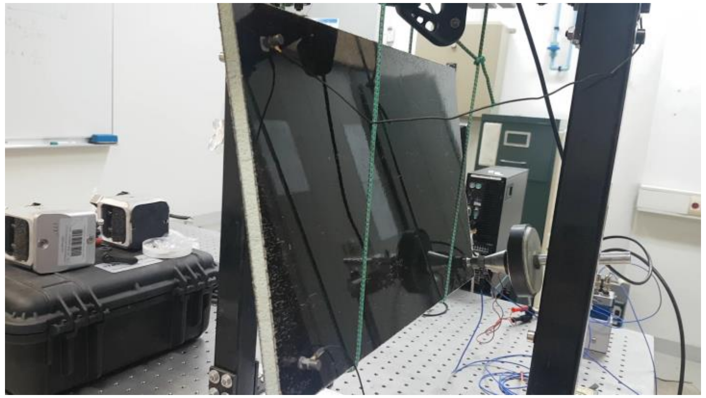
Novel method for the measurement of damping at microscale

Measurement of the **elastic and damping properties at microscale**

Mapping of properties in the **fibers**, in the **matrix** and in the **interface**

Modal analysis of composite panels



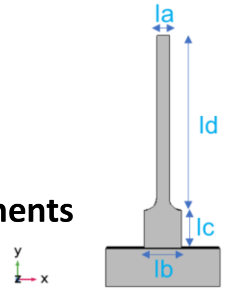


Modal analysis of composite beams and plates

Minimization of **boundary conditions effect**

Skins and sandwich composites

Damping identified from **scanning laser vibrometry measurements**

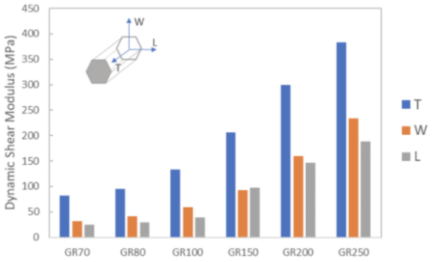


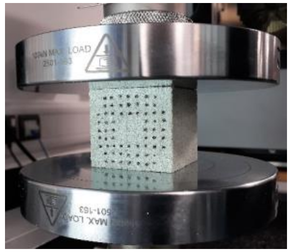
Micro and macro analysis of recycled PET foams

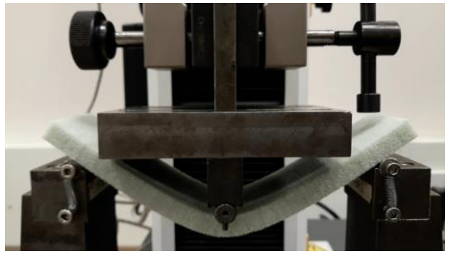
Commercial **recycled foam** to be used as **composite core**

Mechanical and **acoustic** properties

Analysis of a set of grades

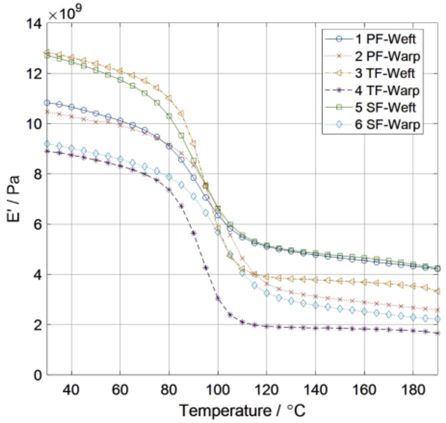


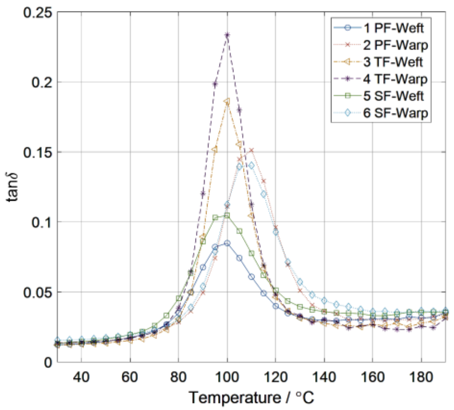




ENVIRONMENTAL PARAMETERS

Temperature and frequency: Dynamical Mechanical Analysis of composite skins

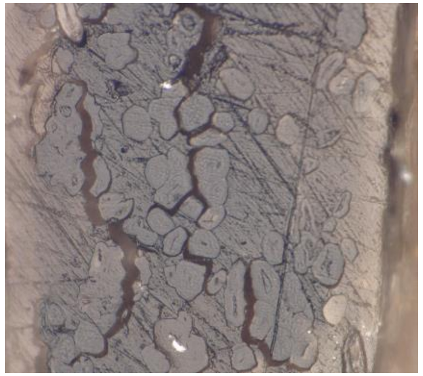




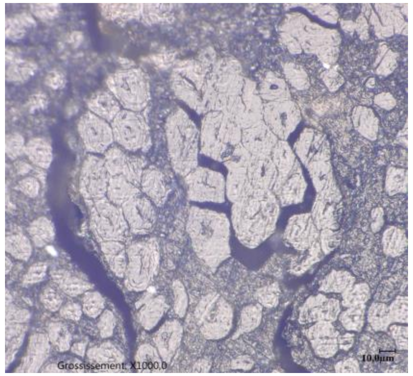
Temperature has a **significant impact** on elastic and damping properties
Maximum damping capabilities obtained at **glass transition temperature** (at the cost of a reduction of mechanical stiffness)
Constant damping properties at ambiant temperature
Low frequency depedency except close to glass transition

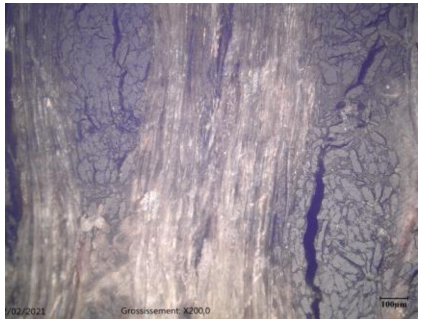
Moisture

FGCR

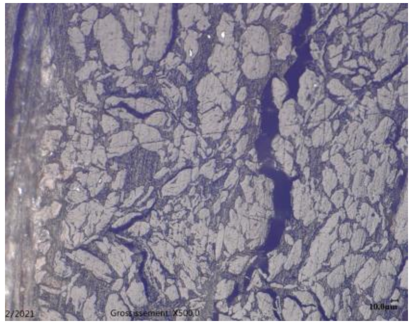


FGUD





H4

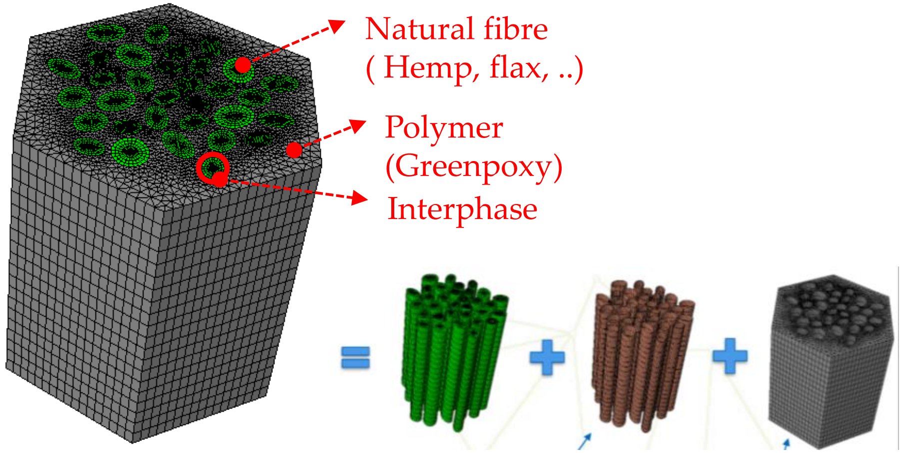


H6

Increase of damping capabilities (1.2-1.5x) **with humidity,** mainly due to the fiber sensitivity
SEM analysis after drying
Higher dissipation levels due to damage in the composite material

DAMPING CAPABILITIES OF BIO-BASED COMPOSITES

Computational multiscale analysis for the estimation of damping properties of composite structures



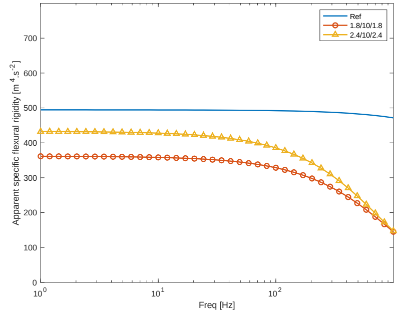
Representative elementary volume (REV) of biocomposite material

Finite Element modelling of Representative Elementary Volume
Mechanical properties of **individual components** obtained by **microscale testings**
Ability to consider **stochastic nature** of natural fibers
Still some work required to obtain confident **damping levels at macro scale**

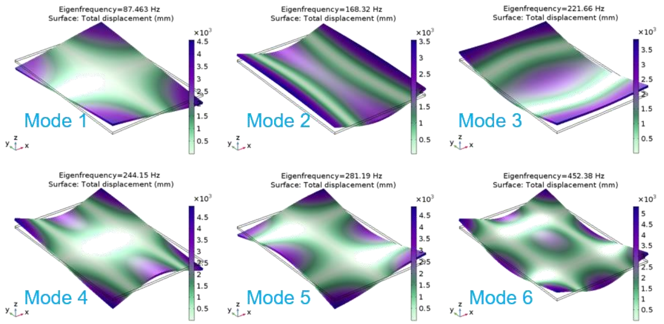
ENGINEERING COMPOSITE STRUCTURES

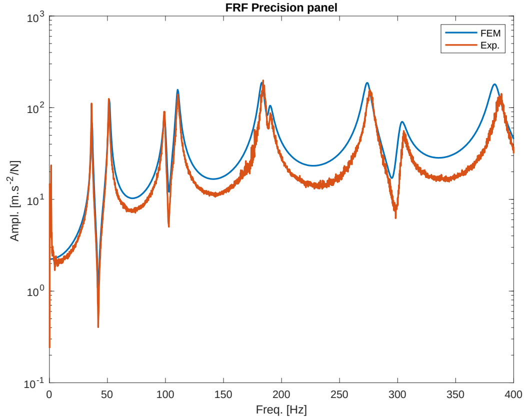
Computation of frequency-dependent properties of multilayered panels

Dispersion analysis: wave-based analysis for **homogeneization of multilayer panels**
Equivalent elastic and damping properties of sandwich panels



Computation of structural modes of multilayered panels





Use of equivalent properties for **fast design of panels** for industrial applications
Excellent correlation with measurements on SSUCHY sandwich panel

See applications in the next talk!

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