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DEVELOPING ADVANCED BIO-BASED COMPOSITES

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BIO-BASED COMPOSITES: ADDING VALUE AND FUNCTIONS THROUGH ENHANCED FUNCTIONALITIES

Vincent Placet (UFC), Aart van Vuure (KU Leuven), Gea Spijkerman (Nouryon), Morvan Ouisse (UFC)

BBI JU
Bio-based Industries Consortium
Horizon 2020
European Union Funding
for Research & Innovation

Final Event *– Videoconference – 9th February 2022*

PROGRAM

Bio-based composites used and developed within the SSUCHY project, an overview (5 min)	Vincent PLACET, University of Franche-Comté
Improving the moisture durability of flax and hemp fibre composites (10-15 min)	Aart VAN VUURE, KU Leuven
Nouryact, a cobalt free accelerator system for unsaturated polyester curing, suitable for non-dried plant fibres (5 min)	Gea SPIJKERMAN, Teamleader Crosslinking, Thermoset and Polymer Additives, Nouryon
Damping properties of bio-based composites (5-10 min)	Morvan Ouisse, ENSMM

5 min for questions/discussion

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IMPROVING THE MOISTURE DURABILITY OF FLAX AND HEMP FIBRE COMPOSITES

Aart van Vuure (KU Leuven)

Bio-based Industries Consortium
Horizon 2020 European Union Funding for Research & Innovation

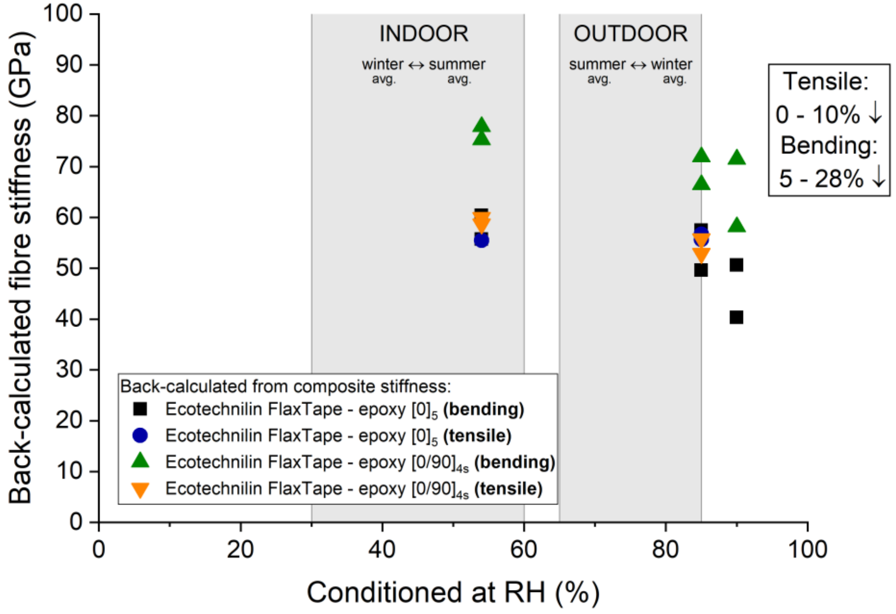
STUDIES ON MOISTURE DURABILITY WITHIN SSUCHY

1) Hygrothermal Ageing, moisture cycling (KU Leuven)
2) Hygrothermal Creep (University of Franche Comté)
3) Hygrothermal Fatigue (University of Franche Comté)

INFLUENCE OF MOISTURE ON BIO-FIBRE COMPOSITES

Typical flax fibre composites

Static effect

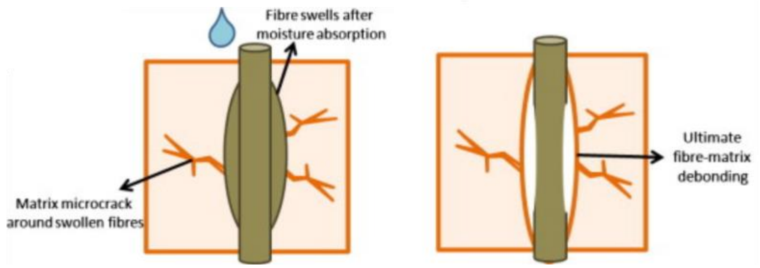


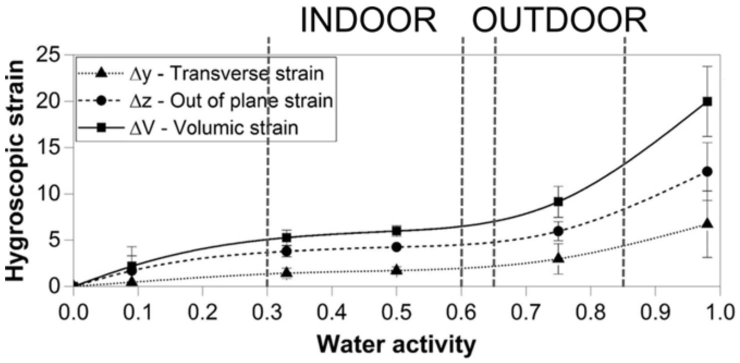
Focus in Ssuchy

Cycling effect

Absorption

Desorption



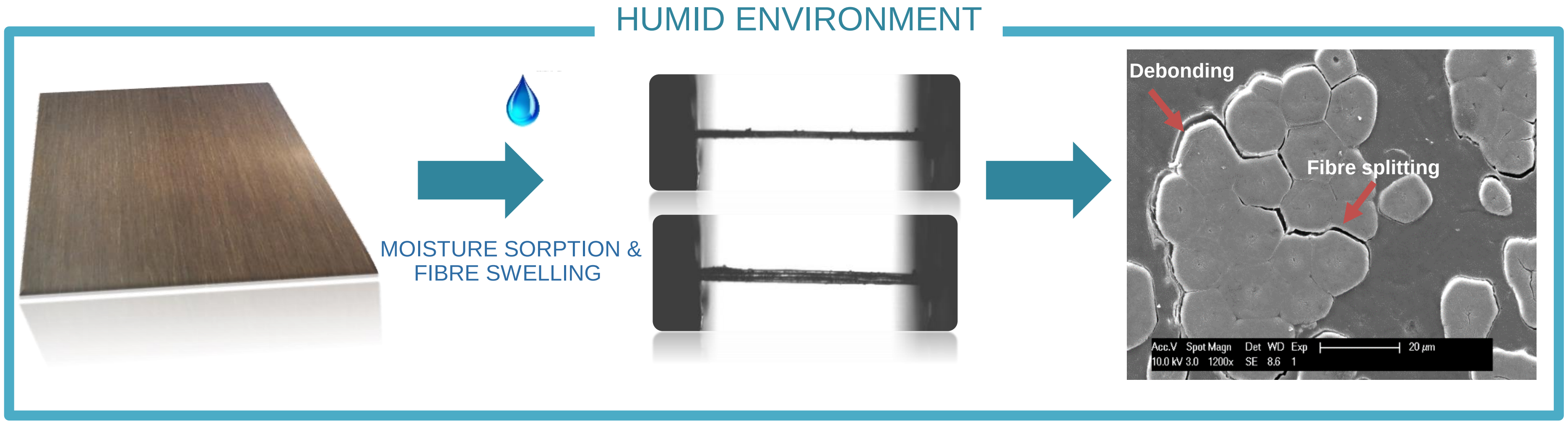


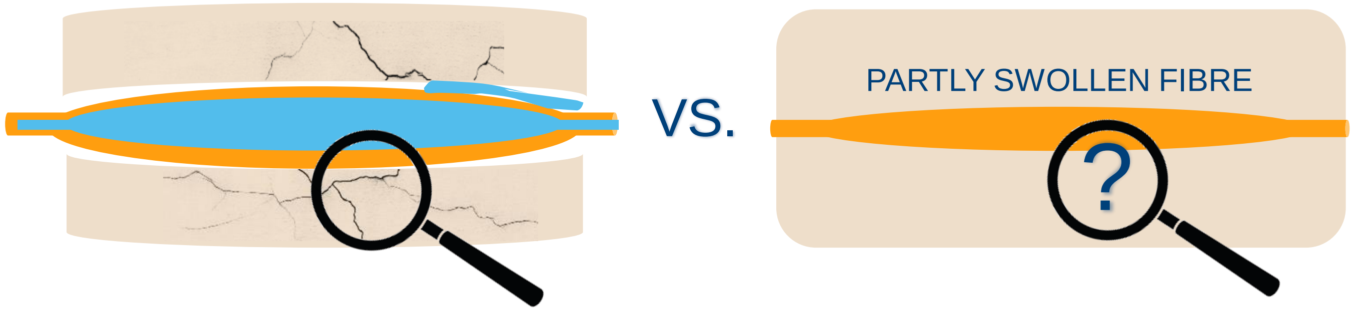
STRATEGIES TO DECREASE EFFECT OF MOISTURE CYCLING

1) Choose less moisture sensitive natural fibres, e.g. bamboo fibre
2) Lower the Equilibrium Moisture Content (EMC) of the fibres; chemical treatment
3) Reduce the swelling of the fibres; constraint from the matrix?
4) **Turn water inside the fibres into an advantage, process with water inside the fibres; pre-swollen fibres**
5) **Coatings (of fibres** or composite**); slow down water diffusion and mitigate peak loads**
6) Ensure a good fibre-matrix adhesion, also at high humidity

MOISTURE DURABILITY OF NATURAL FIBRE COMPOSITES BY USING NON-DRY FIBRES

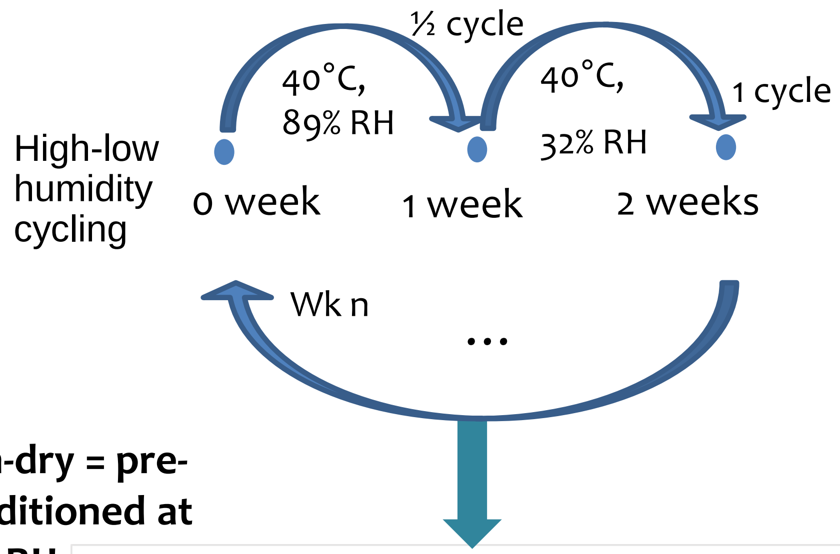
PhD Morissa Lu



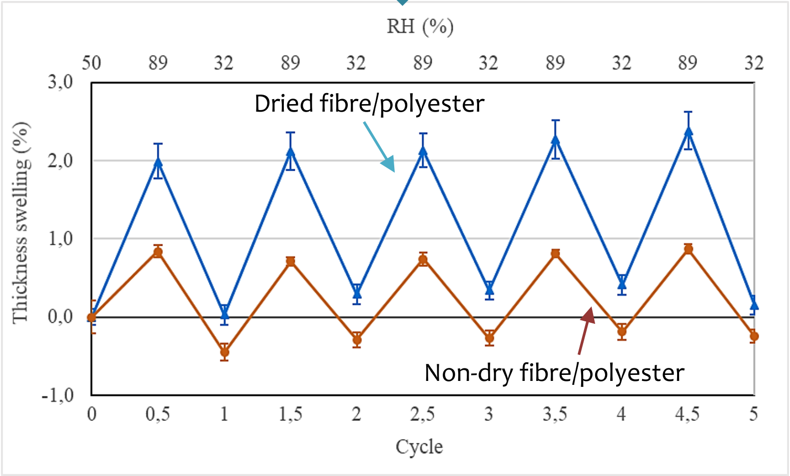


Less moisture sorbed?
Less microcracks?
Less voids?
Will there be less damage at the interface?

NOT DRYING THE NATURAL FIBRES LEADS TO BETTER STRENGTH RETENTION AFTER MOISTURE AGEING (LESS DAMAGE)



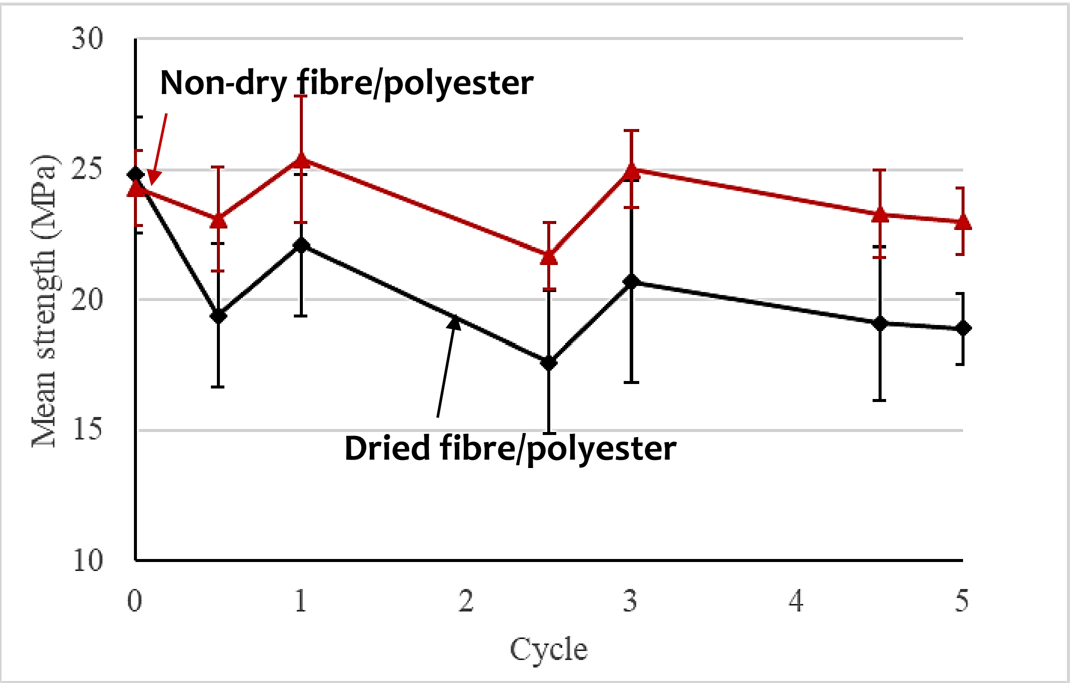
Non-dry = pre-conditioned at 80% RH



Swelling/shrinking of composites

Bending test results (transverse)

Testing: After reconditioning at standard condition



MM Lu*, AW Van Vuure. ***Comp Part A 2019***

Non-water sensitive polyester resin with Nouryact accelerator from Nouryon

SECOND, EXTENSIVE STUDY CONFIRMED RESULTS

Composite samples:

Polyester +
- dried flax fibre
- fibre (50% RH)
- fibre (80%RH)

Epoxy +
- dried flax fibre
- fibre (50% RH)
- fibre (80%RH)

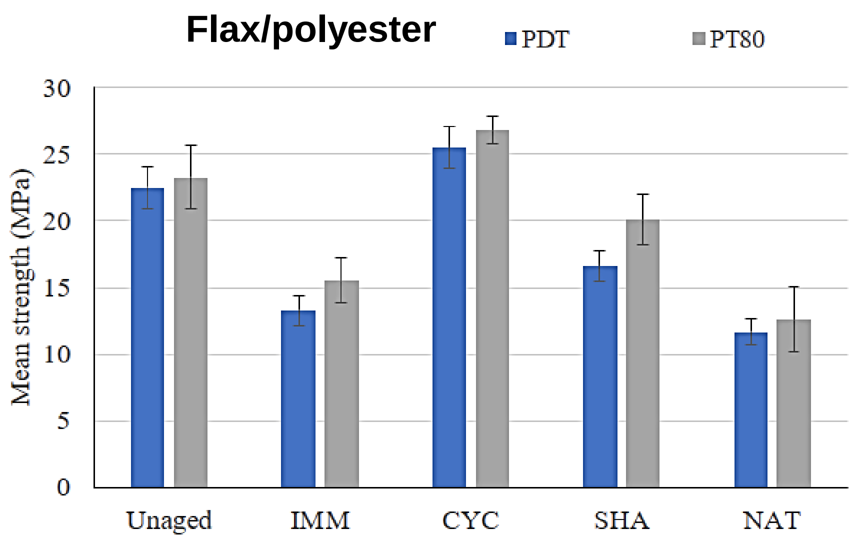
Longitudinal
Transverse

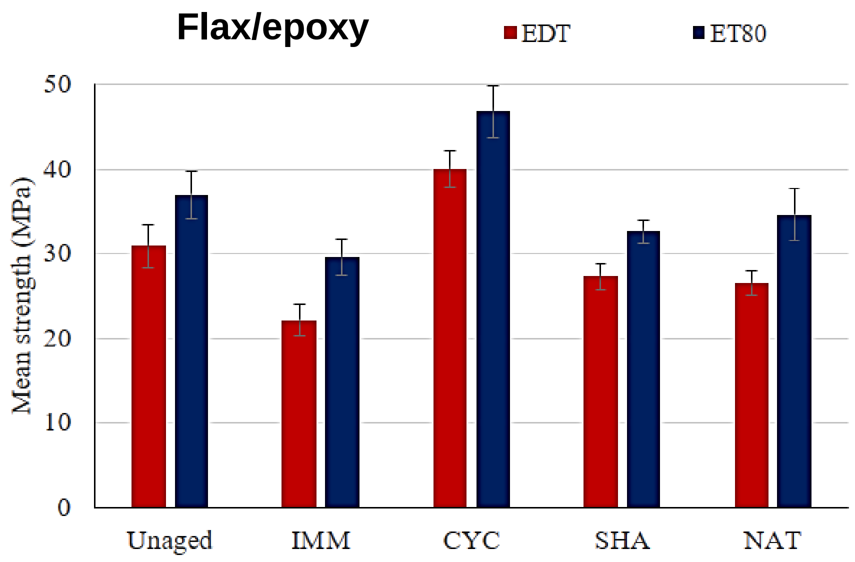
Reference materials:

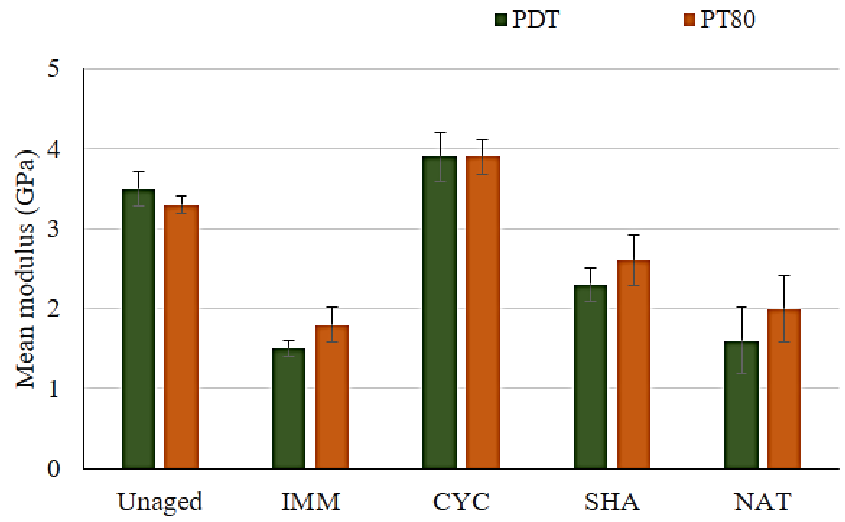
E-glass/epoxy
European beechwood
Polyester resin
Epoxy resin

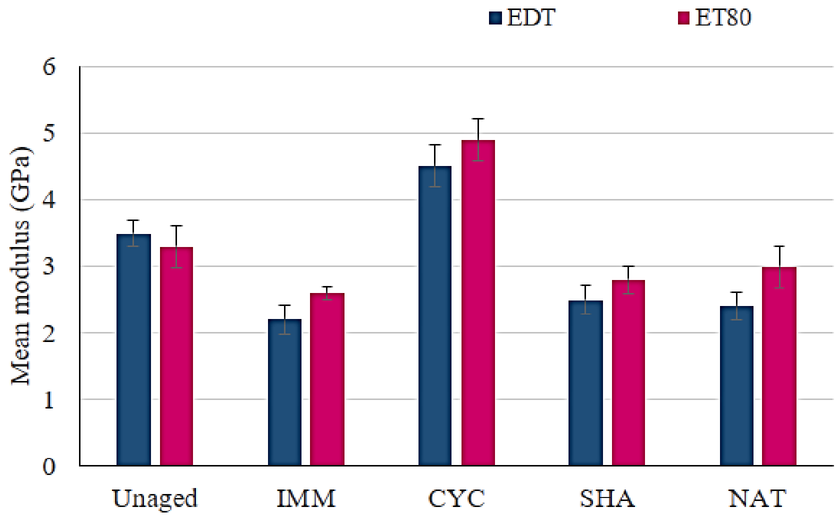
Ageing tests

SUMMARY OF SECOND STUDY









Comparison Protocols:

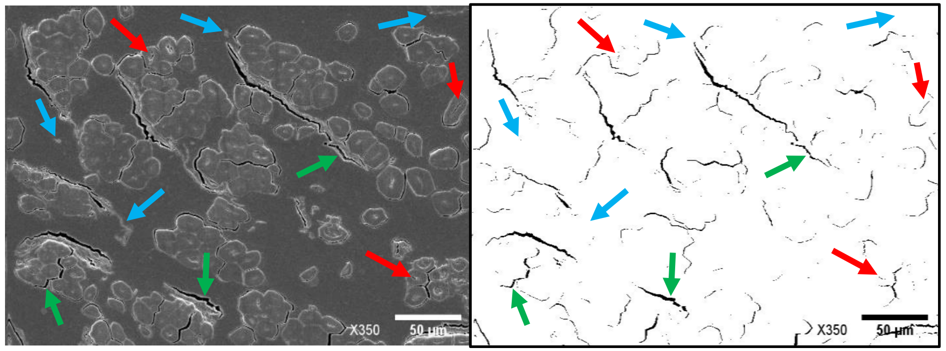
Immersion (IMM), Cycling (CYC), Shaded (SHA), Natural ageing exposed to sunlight (NAT)

Other conclusions:

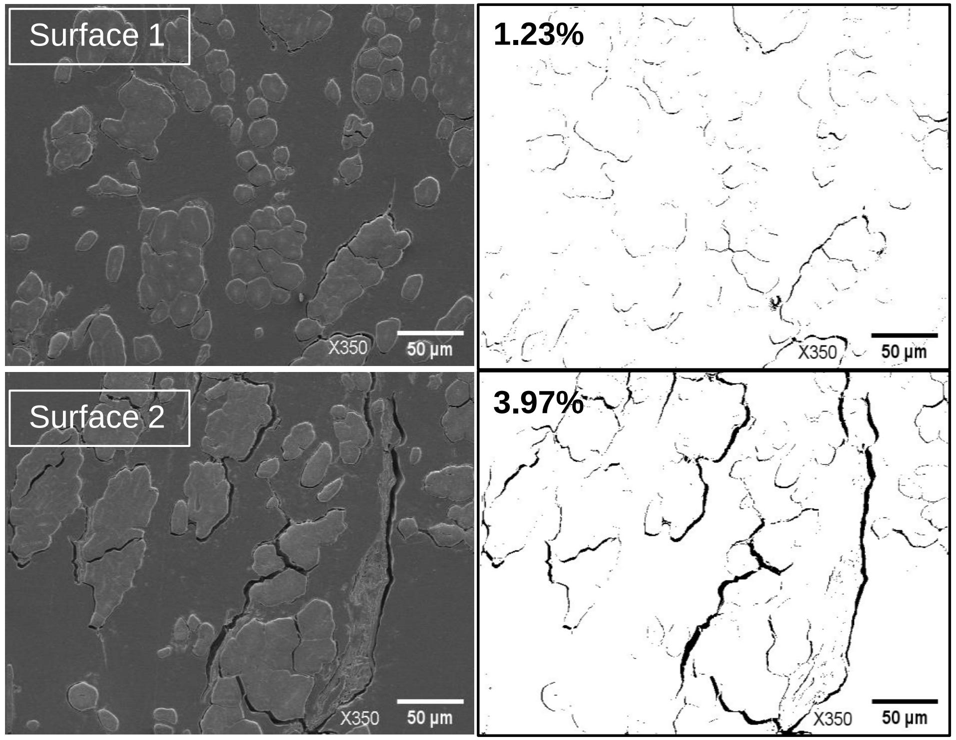
- **Immersion test seems more predictive of outdoor ageing for UNCOATED samples (leaching?)**
- **Cyclic samples recover (20 cycles)**

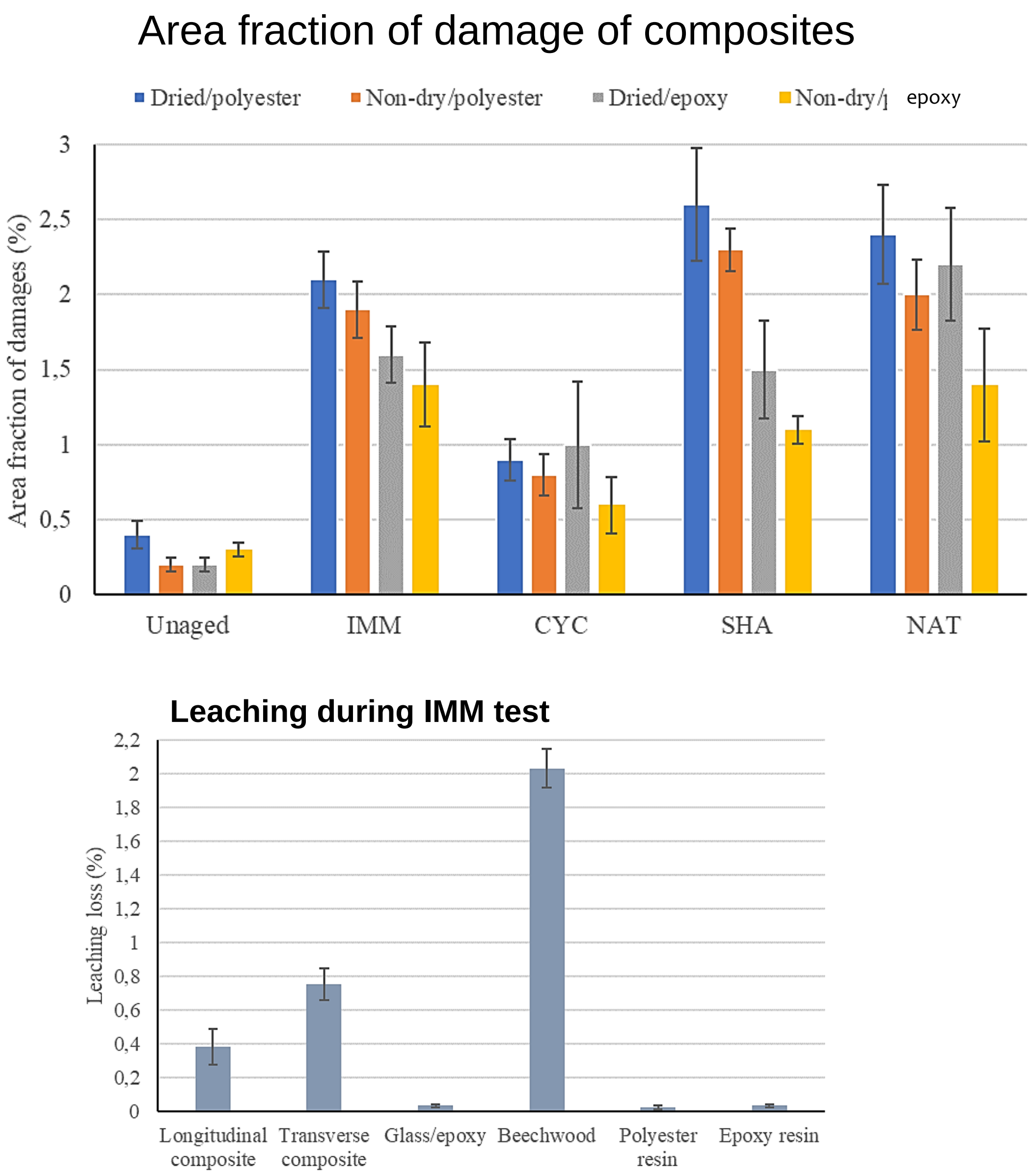
DAMAGE AFTER DIFFERENT AGEING PROTOCOLS

SEM and ImageJ



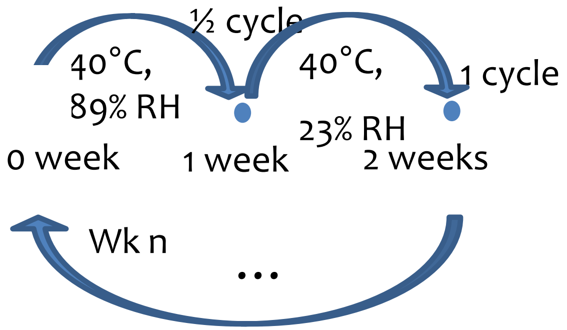
Dried flax/polyester after NAT test



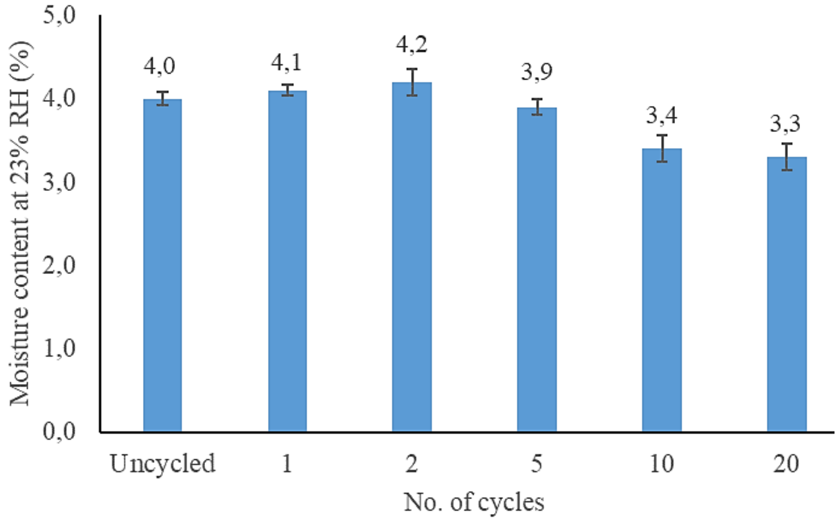


DOES LONG MOISTURE CYCLING LEAD TO STRONGER NATURAL FIBRES?

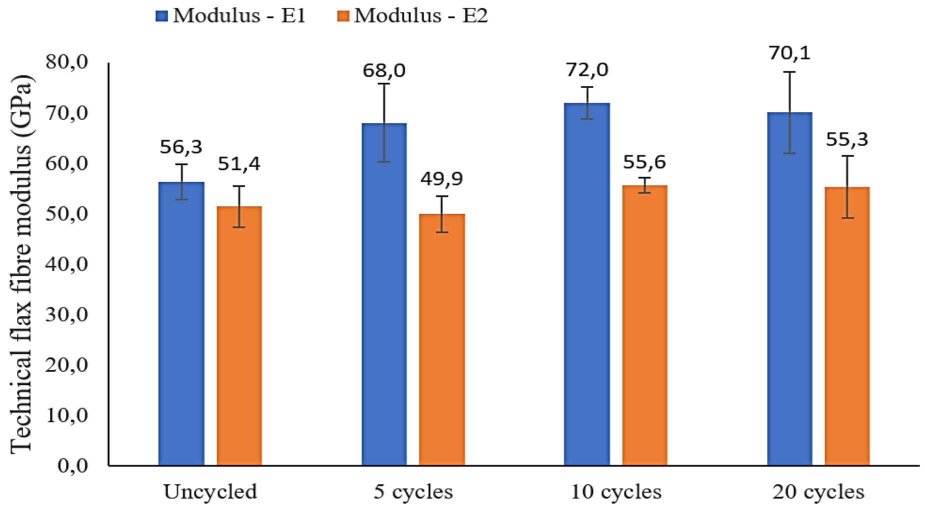
High-low humidity cycling



Moisture content vs. # of cycles

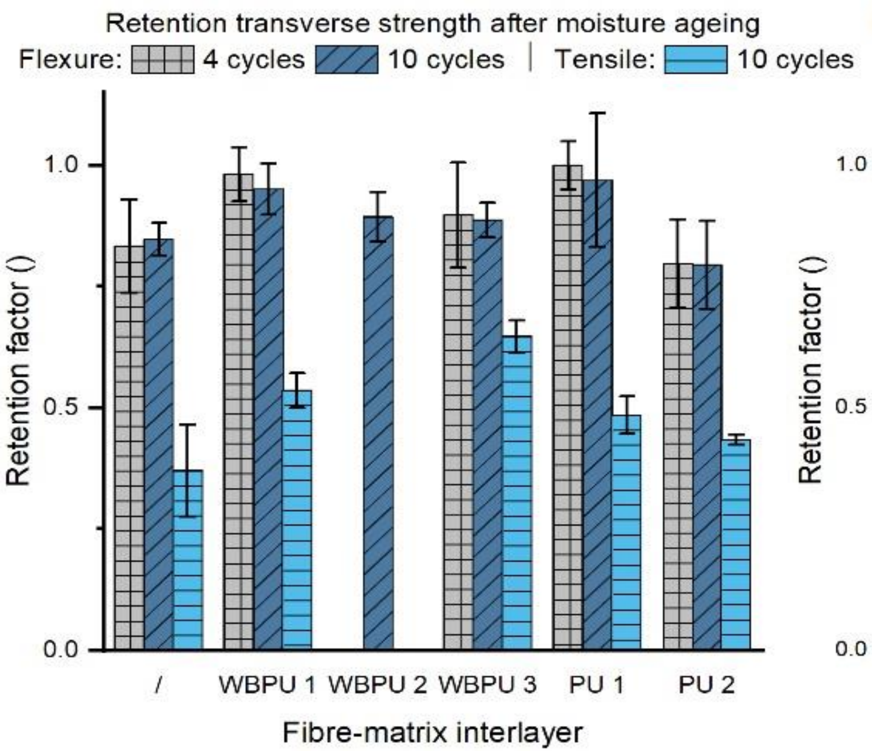


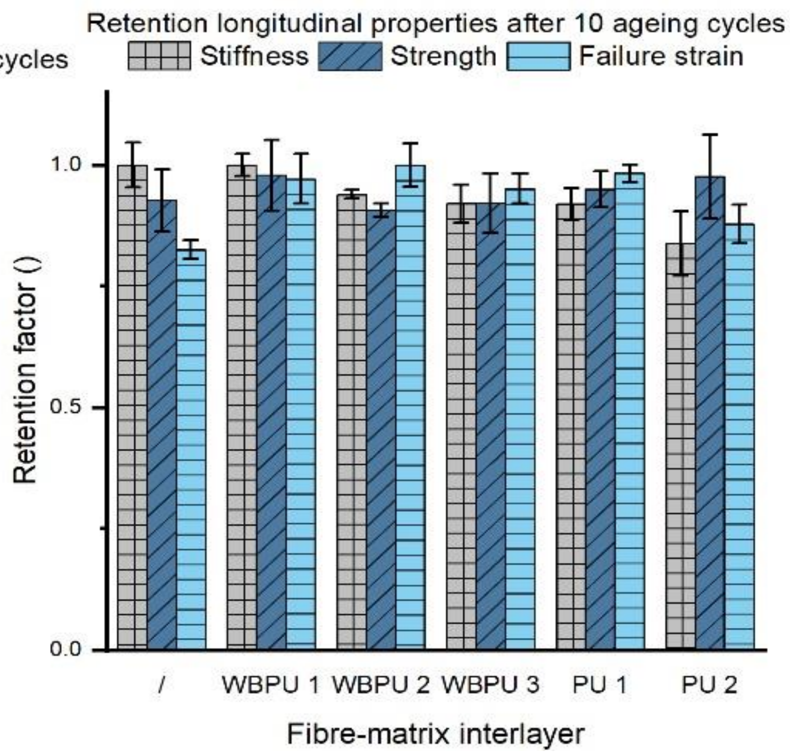
Back-calculated tensile properties of technical fibres (IFBT)

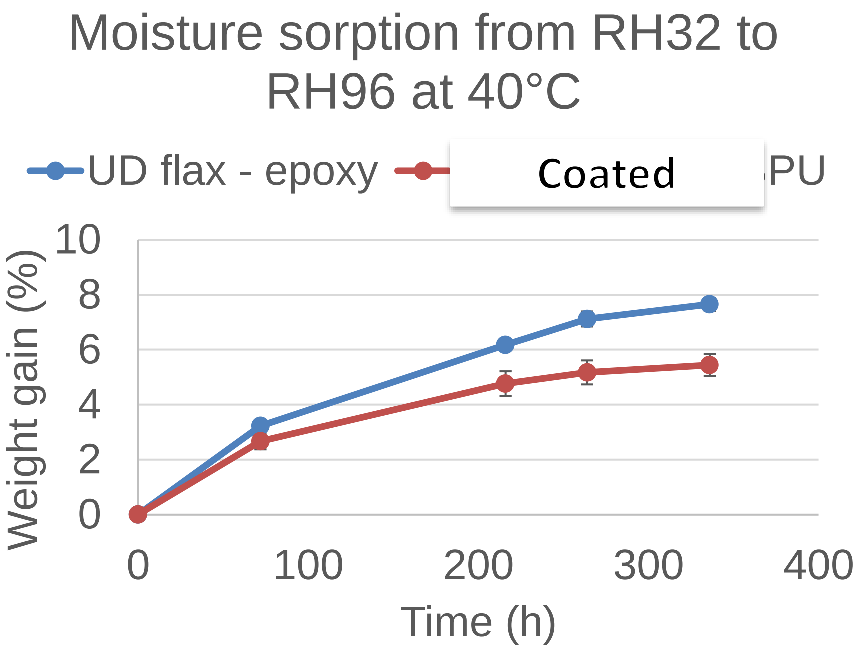


Fibres stiffen / strengthen after cycling !!

ANOTHER SSUCHY STRATEGY TO LOWER MOISTURE SENSITIVITY: FIBRE COATINGS







HYGROTHERMAL CREEP

PhD Benjamin Sala, UFC, 2021

- Creep (& recovery) testing in various hygrothermal conditions, of core materials, skin materials and sandwich structures
- Creep models (semi-emperical), take into account fibre stiffening under load

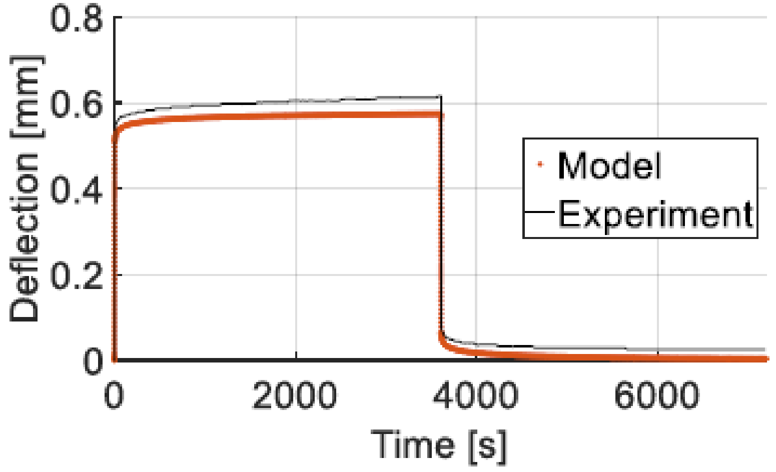


Figure 2. Model/experiment comparison of the evolution of the deflection of sandwich material made of balsa core and Flaxtape reinforced composite skin

Other conclusion: *Variability* of elastic and time-delayed properties of PFCs is significantly lower than at the fibre scale and in the same order of magnitude as for glass fibre composites.

(HYGROTHERMAL) FATIGUE

Probing high-cycle fatigue at higher frequency (30 Hz)
* Is there a fatigue limit?

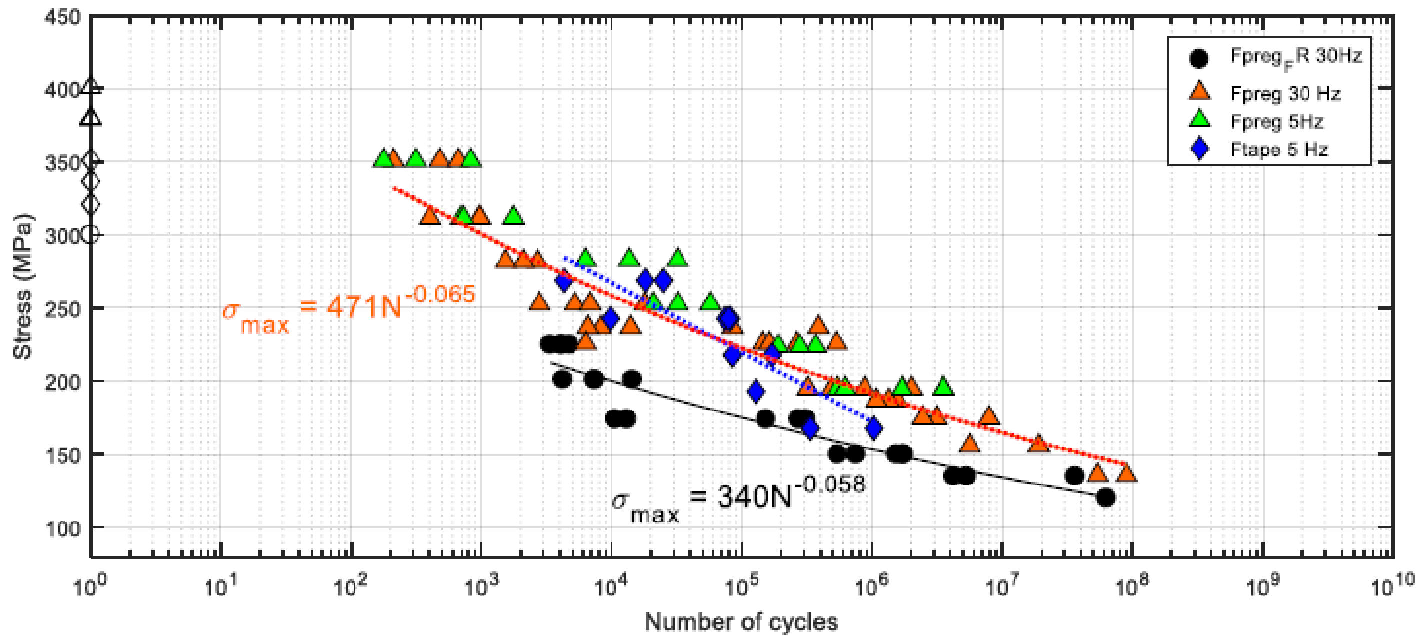


Figure 2: S-N curves recorded for the flax/epoxy composite manufactured in autoclave and used for the dashboard demonstrator (black symbols). Results are compared to the ones obtained for UD flax/epoxy composites manufactured using thermocompression and described in the previous section

(HYGRO)THERMAL FATIGUE

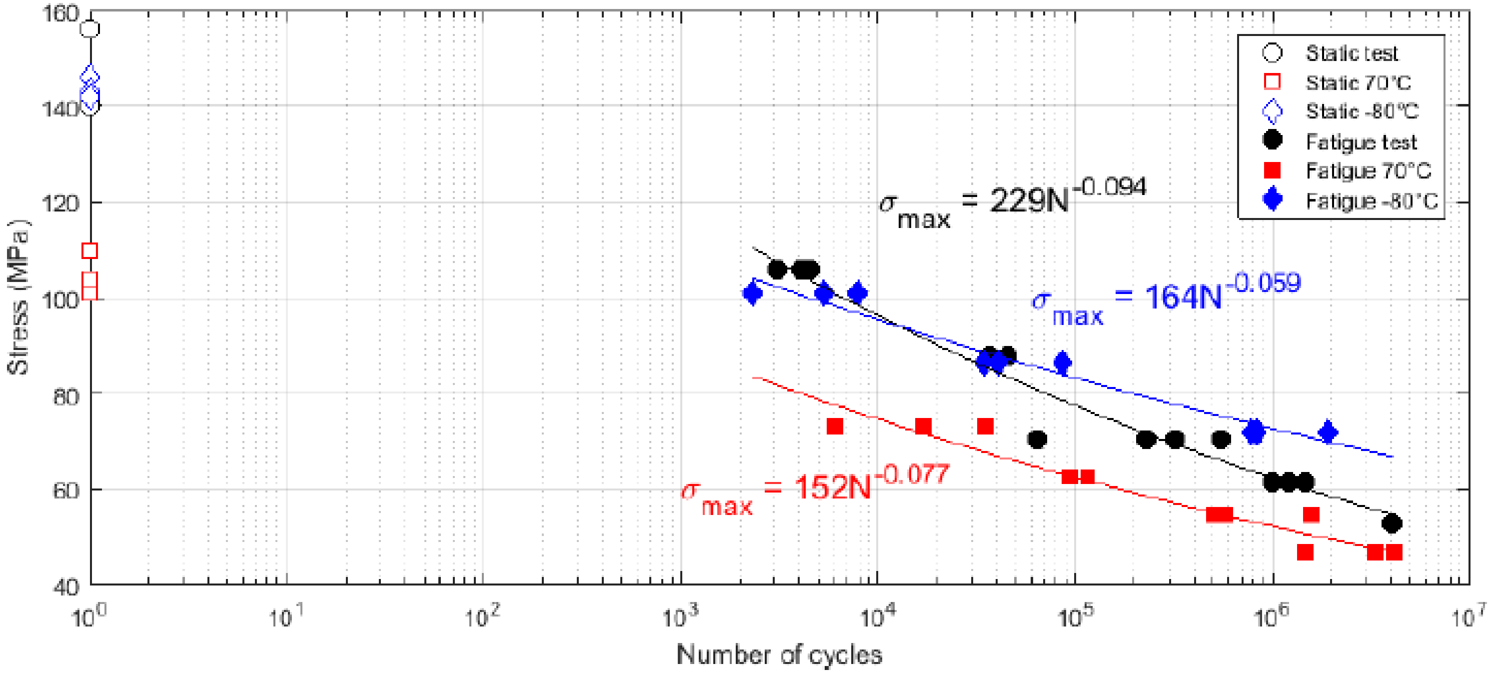


Figure 4: S-N curves recorded for the woven hemp fabric/GreenPoxy composites tested in ambient conditions (black symbols), at -80°C (blue symbols) and at 70°C *(red symbols).*

Stiffening at lower temperature

CONCLUSIONS

- A wealth of new data on the durability of plant fibre composites
- Not drying the natural fibres has durability benefits and saves time and energy (if the resin and processing allow)
- Fibre coating shows promising results in improving moisture resistance
- Surprisingly, plant fibres recover and even increase in strength after prolonged cyclic moisture loading

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