Hygrothermal Fatigue of Structural Biocomposites

Damage analysis and lifetime prediction

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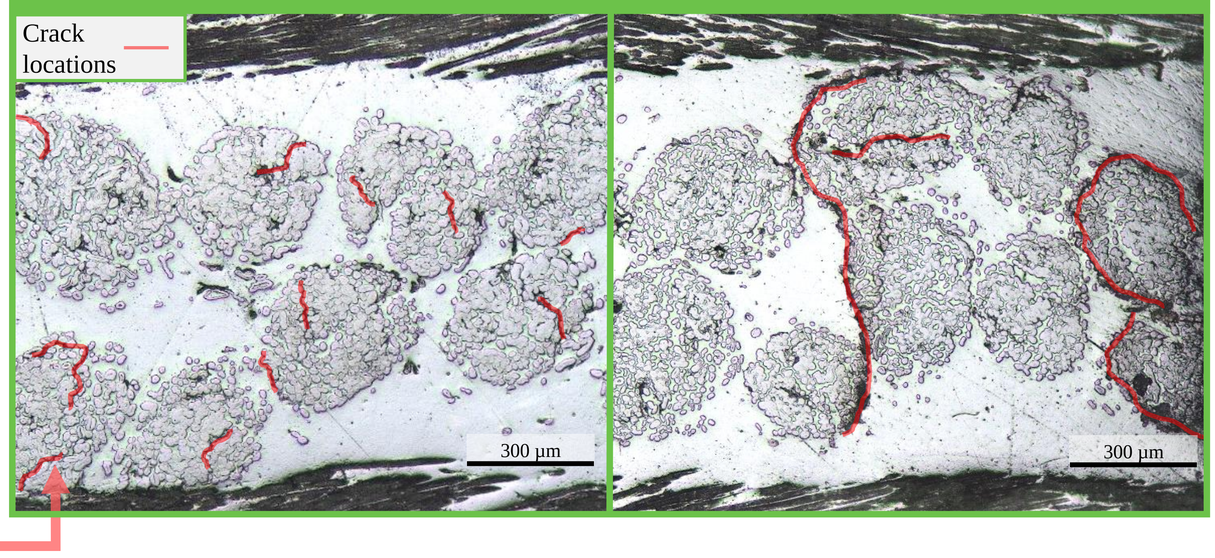
Hygrothermal effects in biocomposites

Natural fibres such as flax quickly exchange moisture with their environment which causes their swelling and shrinkage. Moisture exchanges can therefore create internal stresses in biocomposites as natural fibres experience bigger dimensional changes than the surrounding resin, ultimately leading to internal damage. To this day, the effect of this internal damage on mechanical properties is not well understood but might be critical to the safe and durable design of biocomposite structures.

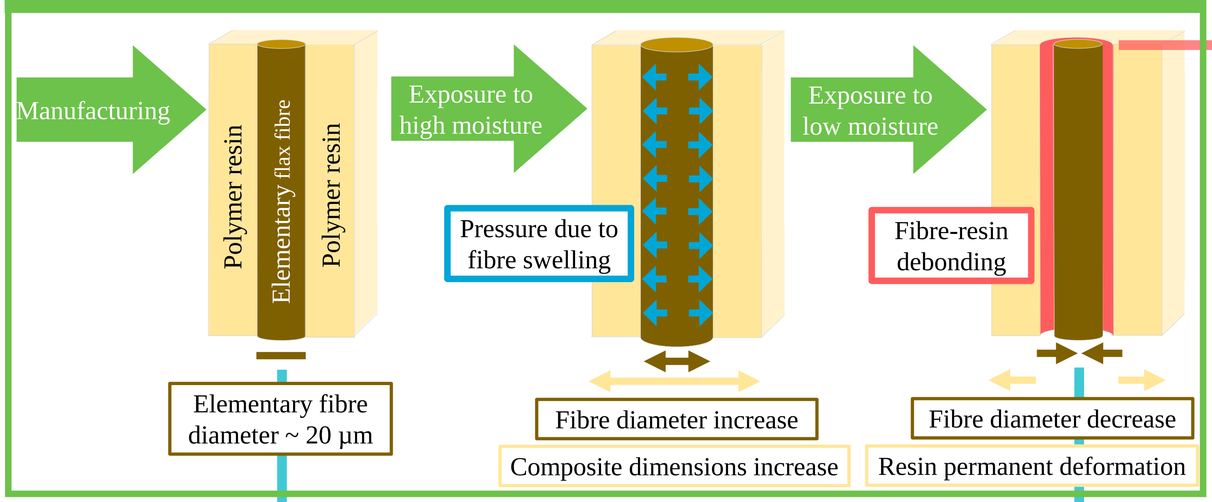
Cross-Section Optical Microscopy

Pure cyclic hygrothermal ageing

Pure mechanical loading



Flax fibre swelling in composite



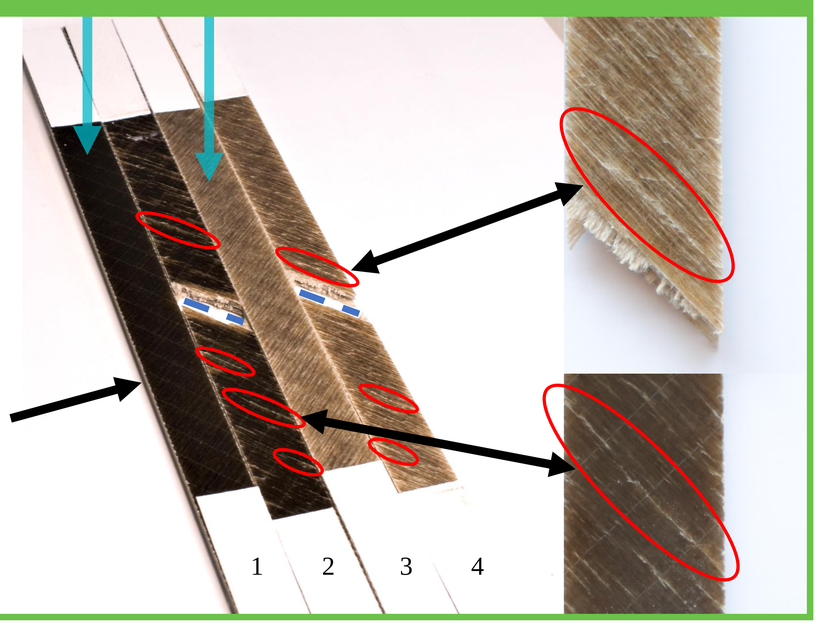
How are the mechanical properties of natural fibre reinforced polymer composites affected by the moisture and temperature of their environment?

Pristine and Tested Specimens

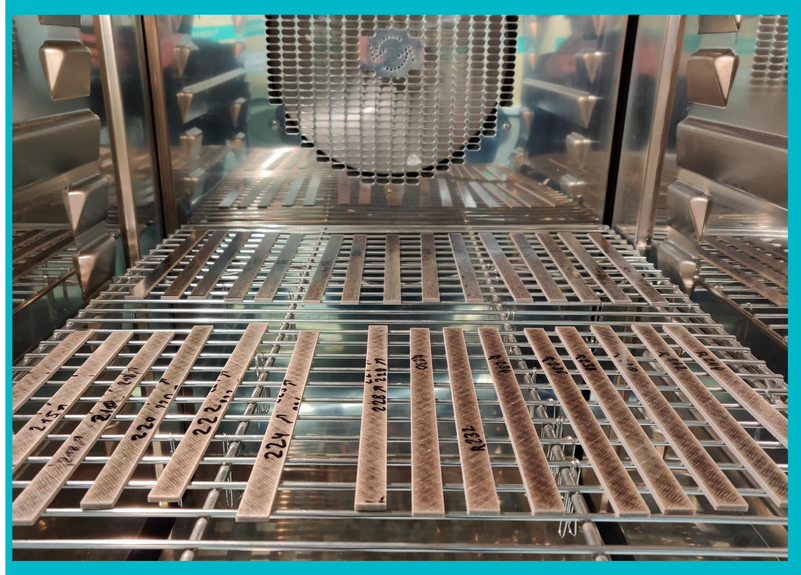
Change of colour due to fatigue and cyclic hygrothermal ageing

Specimens:

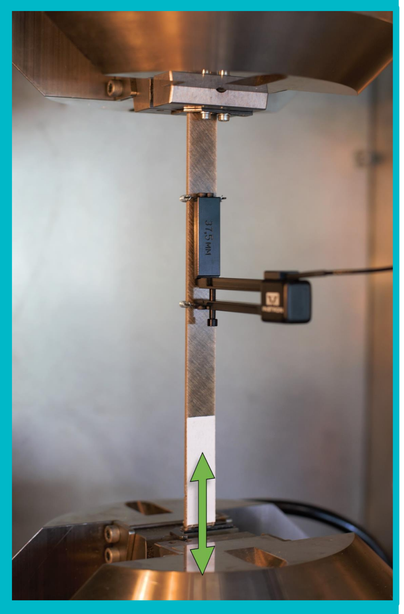
1) Pristine
2) Fatigue failure
3) Cyclic hygrothermal ageing
4) Cyclic hygrothermal ageing followed by fatigue failure



Exposure to moisture and temperature



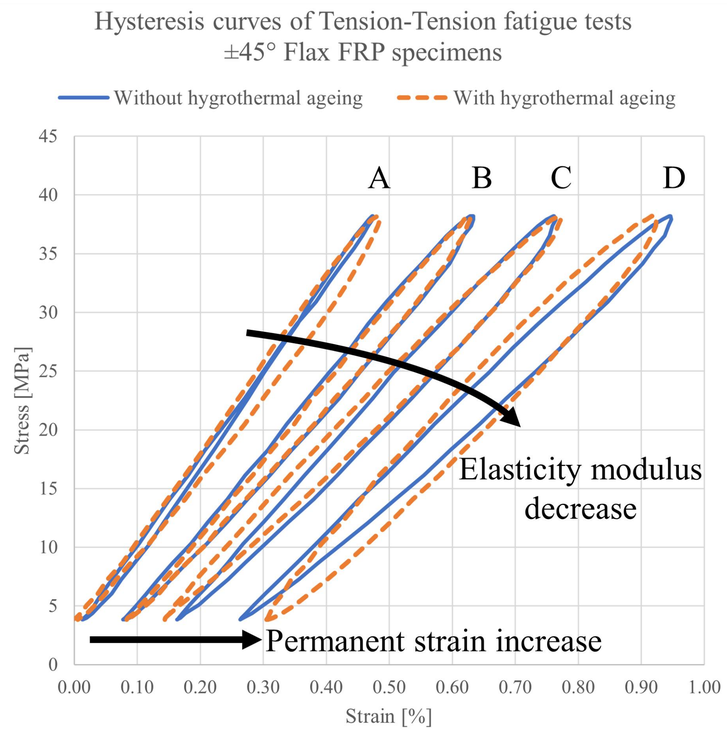
Before mechanical testing in climate chamber:
- Cyclic hygrothermal ageing
- Hygrothermal conditioning



During mechanical testing in climate chamber:
- Fixed hygrothermal conditions

Mechanical testing with hygrothermal effects

Cyclic hygrothermal ageing (fatigue)

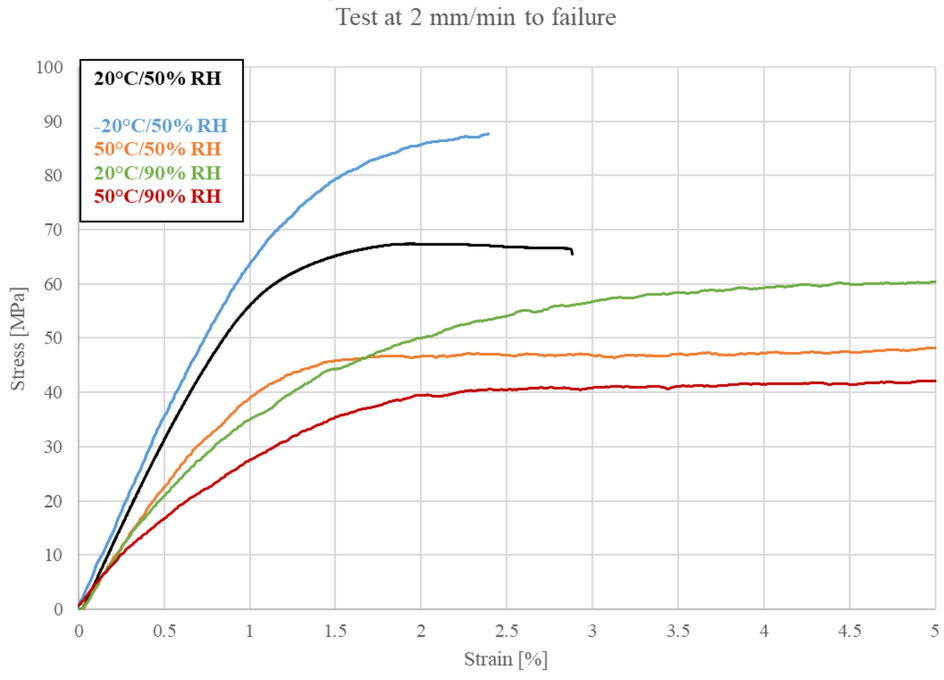


Loading cycle corresponding to the hysteresis:

A) 50 (unaged)
3 (aged)
B) 10’000
5’000
C) 80’000
35’000
D) 190’000
115’000

Hygrothermal ageing cracks accelerate damage growth but the mechanical response follows the same pattern

In-service hygrothermal conditions (quasi-static)



Temperature scales mechanical properties up or down Moisture changes the shape of the mechanical response