







 École polytechnique fédérale de Lausanne



Translaminar fracture toughness characterization in fiber-hybrid thin-ply composites: effect of hybridization

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<u>G. Broggi¹</u>, A. Argyropoulos², J. Cugnoni³, V. Michaud¹

¹Laboratory for Processing of Advanced Composites (LPAC), EPFL, Switzerland ²North Thin Ply Technology SARL, Renens, Switzerland ³Institute of mechanical design and material technologies, HEIG-VD / HES-SO, Switzerland

Contact: guillaume.broggi@epfl.ch

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EPFL Context : thin-ply prepreg



Onset and strength, T800 carbon fiber, QI





Adapted from Cugnoni et al. - ECCM18

EPFL Data reduction: J-integral





EPFL Hybridization mechanisms

	E [GPa]	σ _{ult} [MPa]	ε _{ult} [%]
HR40	375	4410	1.1
34-700	234	4830	2.0



1. Fragmentation and pull-out

2. Extensive delamination and secondary damage

3. Crack bridging



EPFL **Material selection**



Laminate thickness

EPFL Translaminar fracture – Interlayer hybrids



- Architecture effects
- High scattering
- Deviations from linear scaling: hybrid effect?

4 samples per configuration

EPFL **Hybrid effect quantification**



Low strain volume fraction γ





- Need to decouple the two effects .
- Hybrid effect = result different from expectations ٠
- Comparison against a Rule of Mixture (RoM)

EPFL Translaminar fracture – Interlayer hybrids



EPFL Deviation from ROM –Secondary damage



EPFL Translaminar fracture – Interyarn and intrayarn hybrids



- Mild deviation from linear scaling
- Architecture effects

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EPFL Translaminar fracture – Interyarn and intrayarn hybrids



EPFL Translaminar fracture – Interyarn and intrayarn hybrids



Mechanism : low-strain tow bridging

EPFL Energy vs. pull-out length



Maximal length [µm]

• Pull-out length drives the ERR

EPFL A dual-scale modelling approach



Identification of a traction-separation law

Output: energy dissipated by every bundle

EPFL Microscale result



Bundle pull-out length [mm]



Bundle pull-out length [mm]

- Hybridization effect
- Architecture effects
- Long bundles are much more dissipative

EPFL Microscale result



 $\tau_{max} = 20 MPa$

EPFL Macroscale results



- Pull-out drives translaminar fracture toughness
- As ply-thickness decreases, pull-out length decreases
- Fiber-hybridization modulates pull-out length and density
- Translaminar toughness can be predicted according to pull-out distribution

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Thank you for your attention!

Questions?



contact: guillaume.broggi@epfl.ch