Experimental observations on the effect of the 90 degree ply blocks thickness on the strength of 0/90 laminates

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How the fibre-dominated strength of a multidirectional laminate relates to the strength of a UD composite
March 28th, 2023

Projects P18-FR-3360 and PID2021-126279OB-I00

MOTIVATION/OBJECTIVE

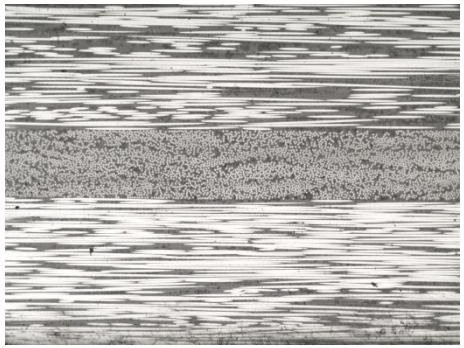
SCALE EFFECT

First transverse damage/crack appearance dependence on the thickness of the 90º ply block in $[0_n\ 90_m]_s$ laminates

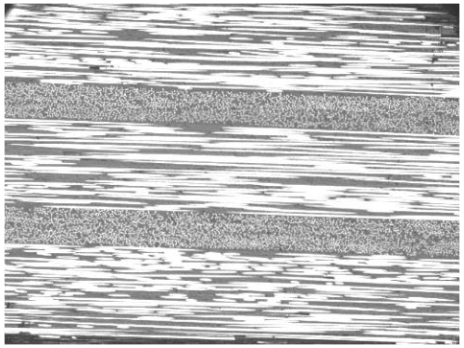
Differences in the damage mechanism ➔ Energetic explanation (*)

0° → USN150

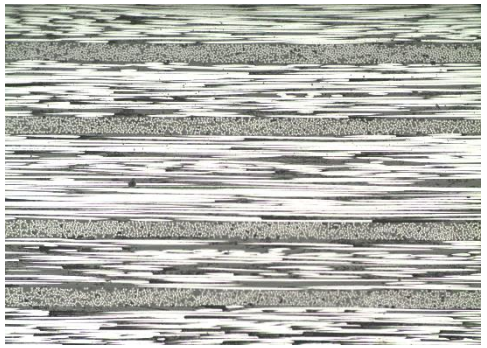
90° → USN50



$[0_3, 90_4, 0_3]$



$[0_2, 90_2, 0_2, 90_2, 0_2]$



$[0, 90, 0, 90, 0, 0, 90, 0, 90, 0]$

OBJECTIVES

- First damage appearance comparison
- Morphologies comparison for the same loading level
- Ultimate loads comparison

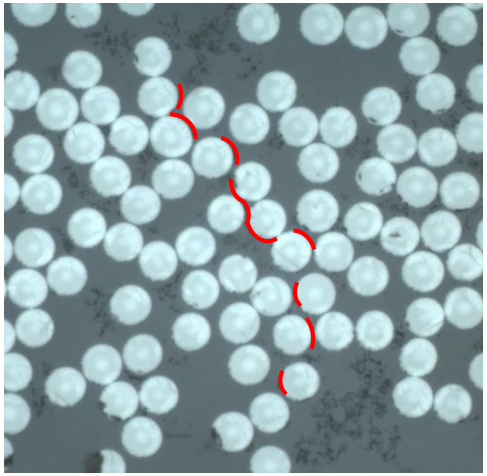
(*)

- París F, Velasco M L, Correa E. The scale effect in composites: An explanation physically based on the different mechanisms of damage involved in failure, Comp Struct 2021;257:113089.
- París F, Velasco M L, Correa E. Micro-mechanical study on the influence of scale effect in the first stage of damage in composites, Comp Sci Tech 2018;160:1-8.
- M.L. Velasco, E. Correa, F. París, The Scale Effect in composites, an explanation based on the mechanisms of damage, 2nd Edition- Modeling Damage, Fatigue and Failure of Composite Materials, 2023. (in press).
- París, F., Velasco, M.L., Correa, E. (2020). Modelling fibre/matrix interface debonding and matrix cracking in composite laminates. En: Multi-Scale Continuum Mechanics Modelling of Fibre-Reinforced Polymer Composites. Editor: Wim Van Paepegem. Elsevier. ISBN: 9780128189856

FIRST DAMAGES

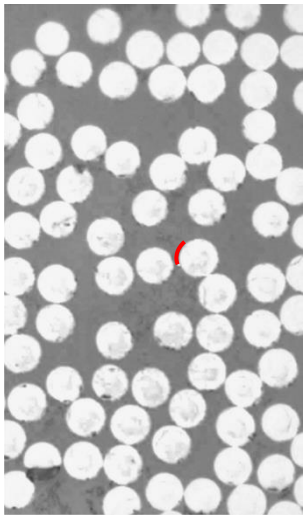
4000N-7000N

$[0_3, 90_4, 0_3]$



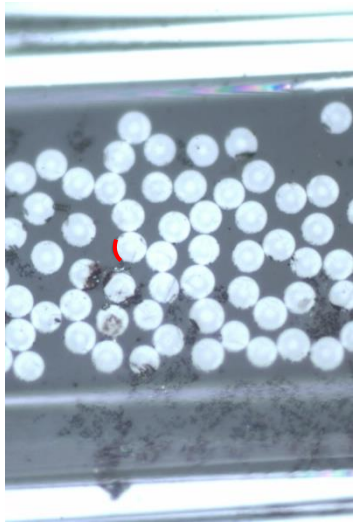
ISOLATED/CONNECTED DEBONDS

$[0_2, 90_2, 0_2, 90_2, 0_2]$



ISOLATED DEBONDS

$[0, 90, 0, 90, 0, 0, 90, 0, 90, 0]$

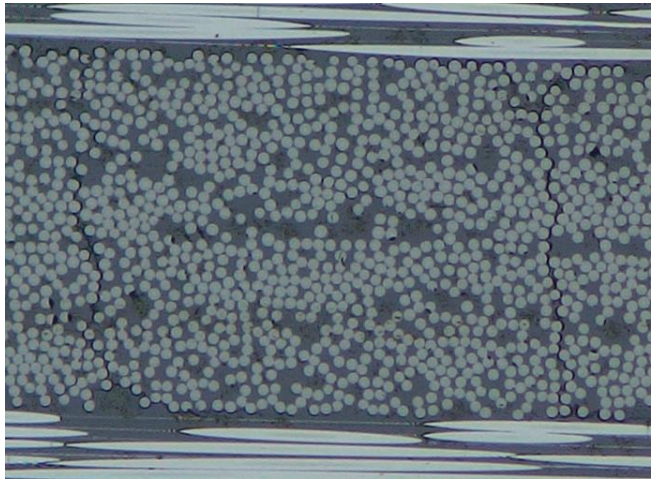


ISOLATED DEBONDS

DAMAGE PROGRESS IN THE 90° PLIES

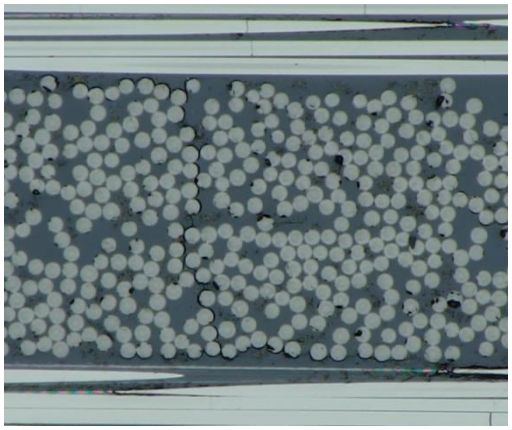
30000N-35000N

$[0_3, 90_4, 0_3]$



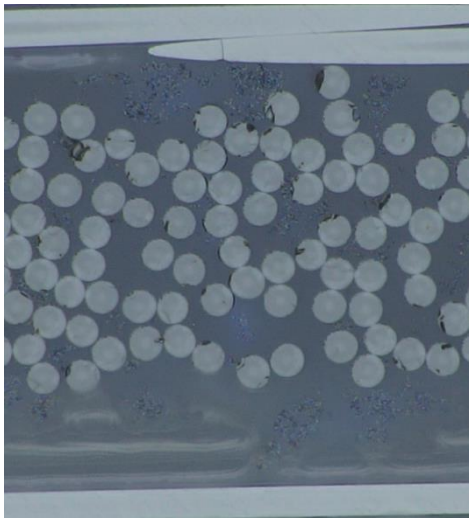
TRANSVERSE CRACKS (SATURATION) AND DELAMINATION

$[0_2, 90_2, 0_2, 90_2, 0_2]$



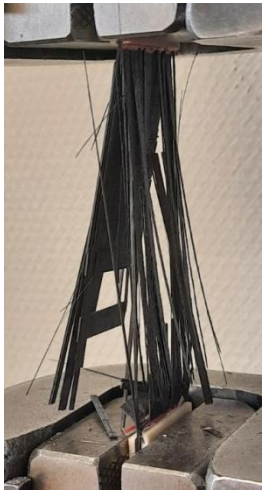
TRANSVERSE CRACKS AND DELAMINATION

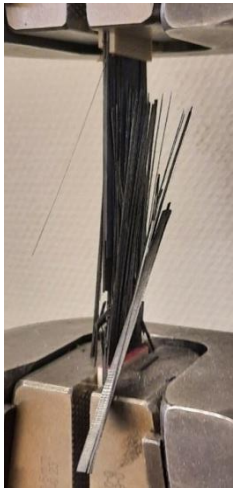
$[0, 90, 0, 90, 0, 0, 90, 0, 90, 0]$



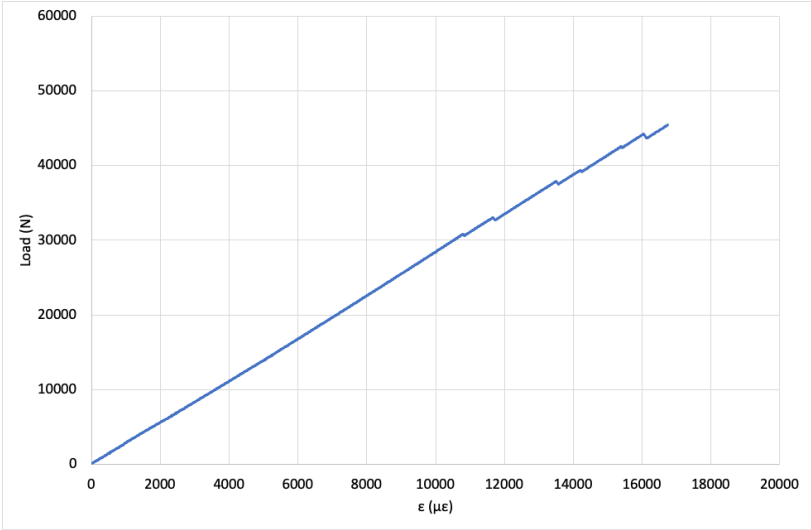
ISOLATED/CONNECTED DEBONDS

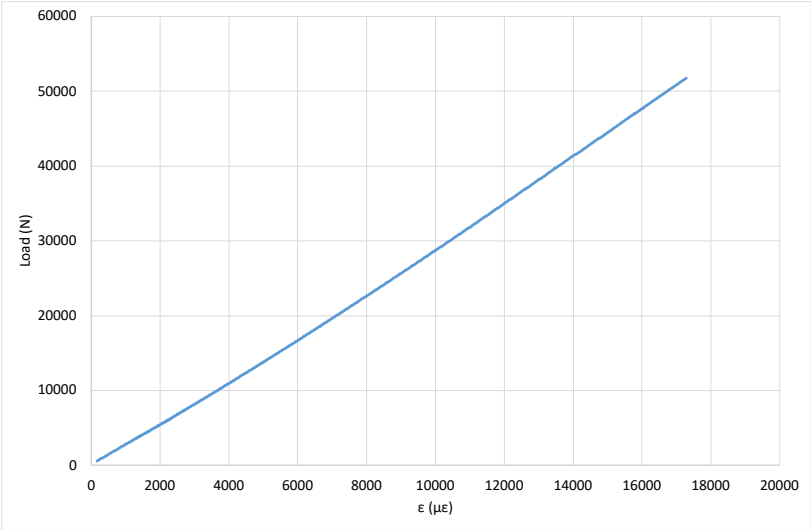
ULTIMATE LOADS





	Rupture values (N)		
	$[0_3, 90_4, 0_3]$	$[0_2, 90_2, 0_2, 90_2, 0_2]$	[0, 90, 0, 90, 0, 0, 90, 0, 90, 0]
P1	41898	56143	51235
P2	45381	54671	51748
P3	42369	49541	56230
P4	48565	54000	56829
Mean value	**44553**	**53589**	**54010**
SD	3087	2843	2927
C.V.(%)	6,9	5,3	5,4

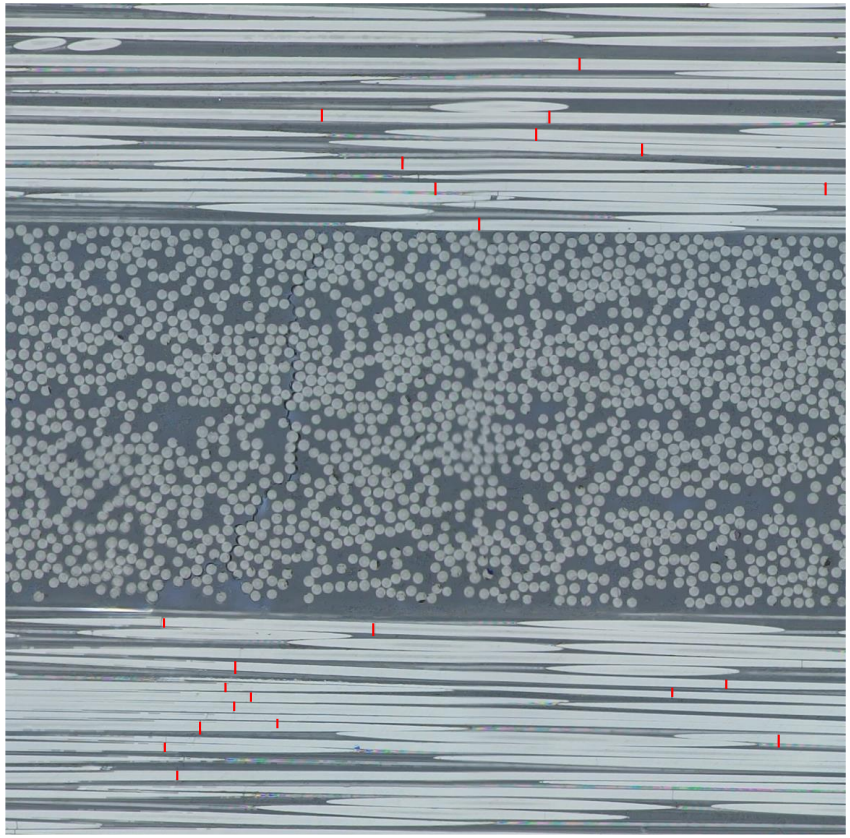




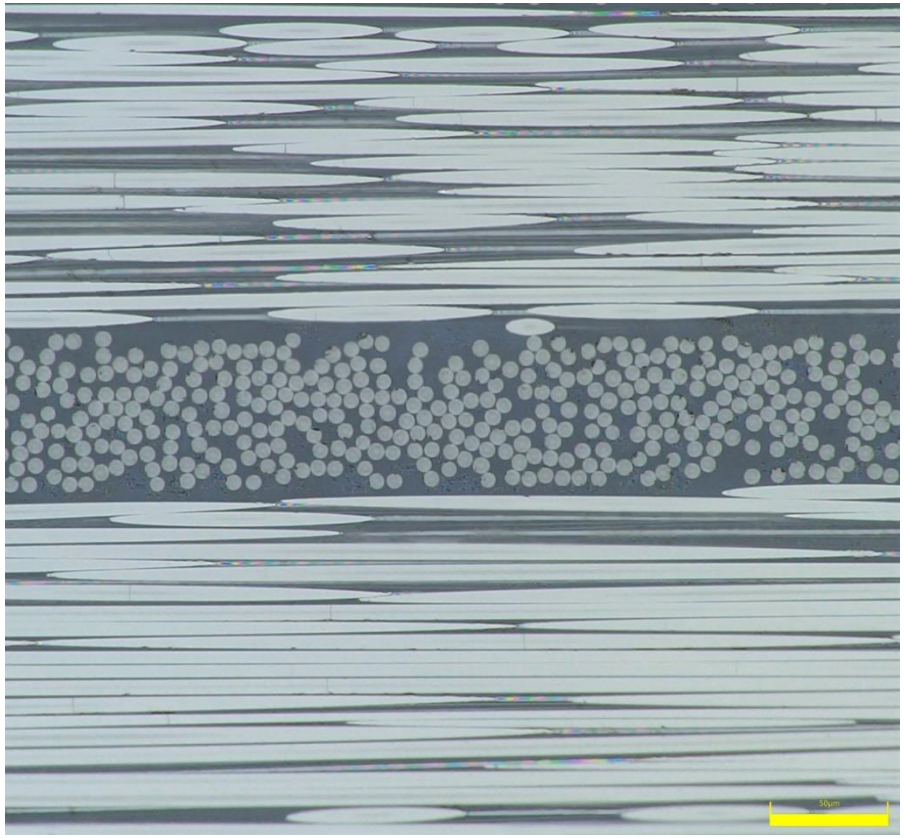
DAMAGE IN THE 0° PLIES

30000N-35000N

$[0_3, 90_4, 0_3]$



$[0, 90, 0, 90, 0, 0, 90, 0, 90, 0]$



GRUPO DE ELASTICIDAD Y RESISTENCIA DE MATERIALES

SUMMARY

First damage appearance comparison	Less advanced as the 90º ply blocks thickness decreases
Morphologies comparison for the same loading level	The less thickness of the 90º ply blocks, the less advanced the damage found both in the 90º plies and the 0º plies
Ultimate loads comparison	20% lower for $[0_4\ 90_3\ 0_4]$

Which are the factors affecting the strength of a cross ply laminate?

- Number of 0º plies involved
- Laminate thickness

Staking sequence? **90º/0º thickness ratio?**

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