



Predicting unnotched strength of QI laminates using UD strength and size effect laws

Dr Xiaodong Xu
28-March-2023

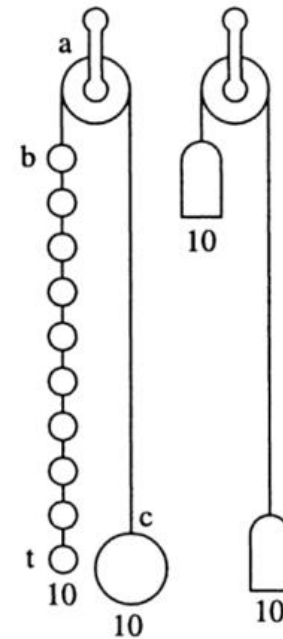


Background

- Leonardo da Vinci in the 1500s stated that “*Among cords of equal thickness the longest is the least strong*”.
- Larger composites are more likely to have a major defect, leading to lower strength based upon the weakest link theory, also known as “Weibull theory”.



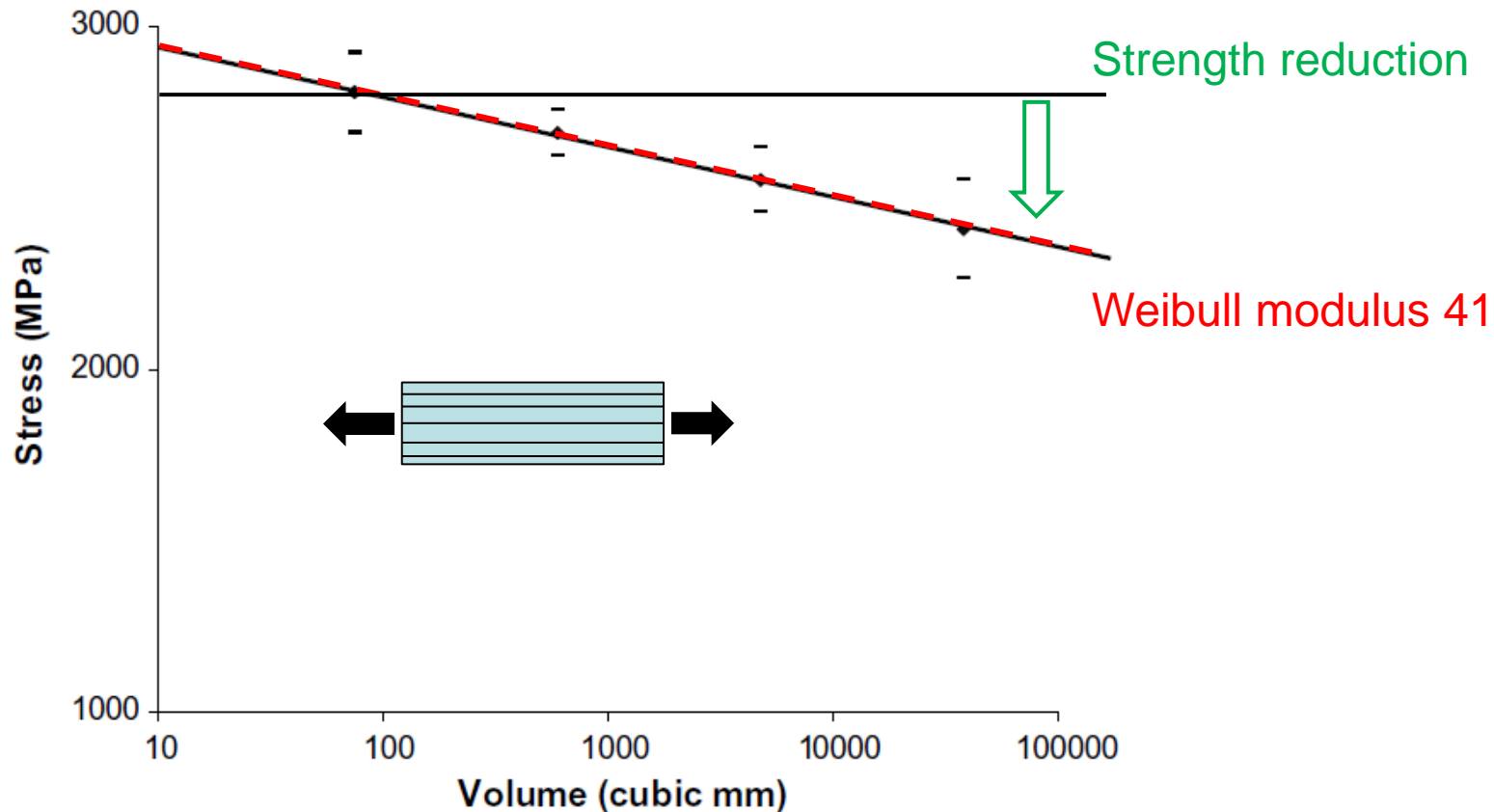
(1452 –1519)



Da Vinci (1500s) L. The notebooks of Leonardo da Vinci. London: Edward McCurdy. 1945.

Scaling of Unidirectional (UD) Strength

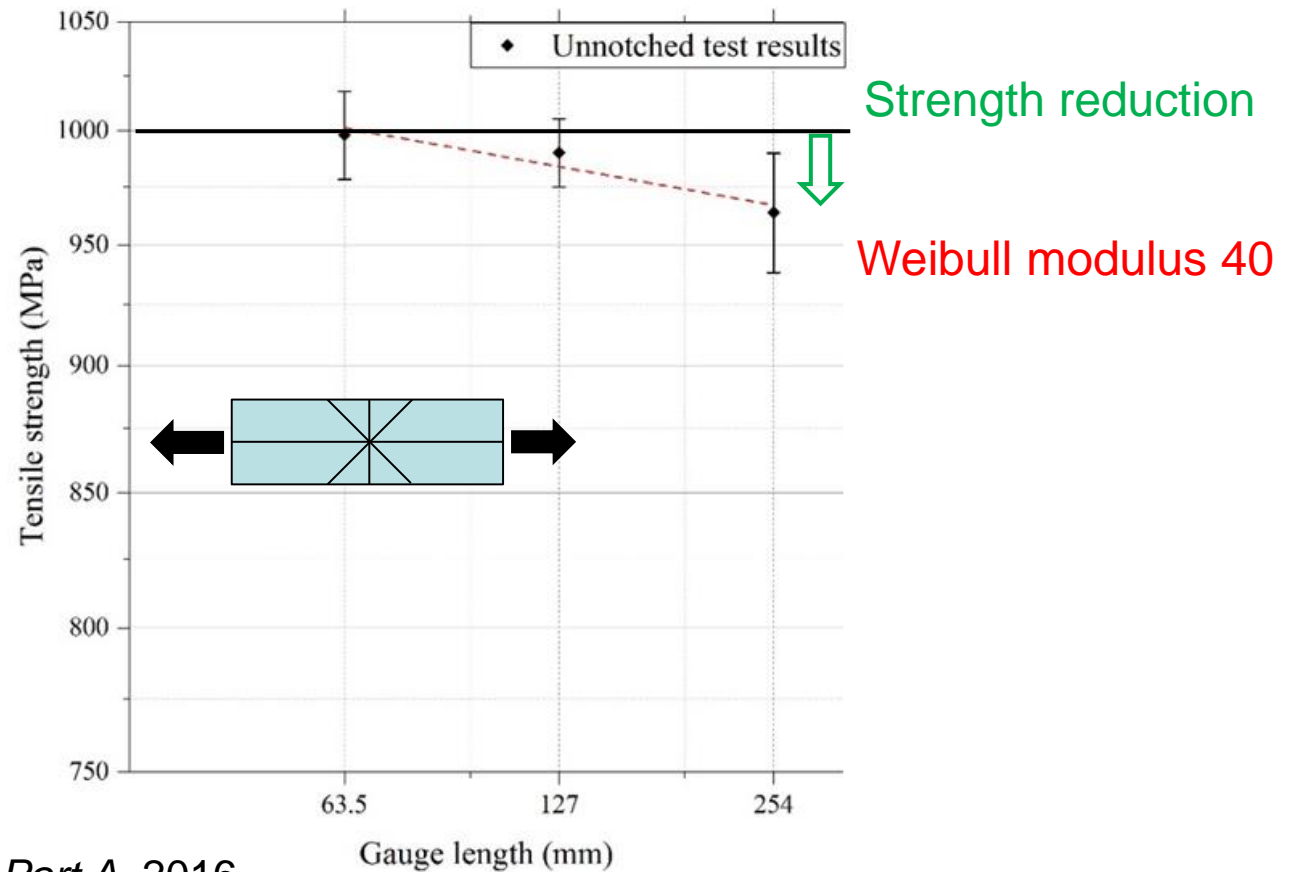
- Larger specimens are more likely to have a major defect, leading to a lower UD strength.



Wisnom MR et al. *Composite Structures*. 2008

Scaling of Quasi-isotropic (QI) Strength

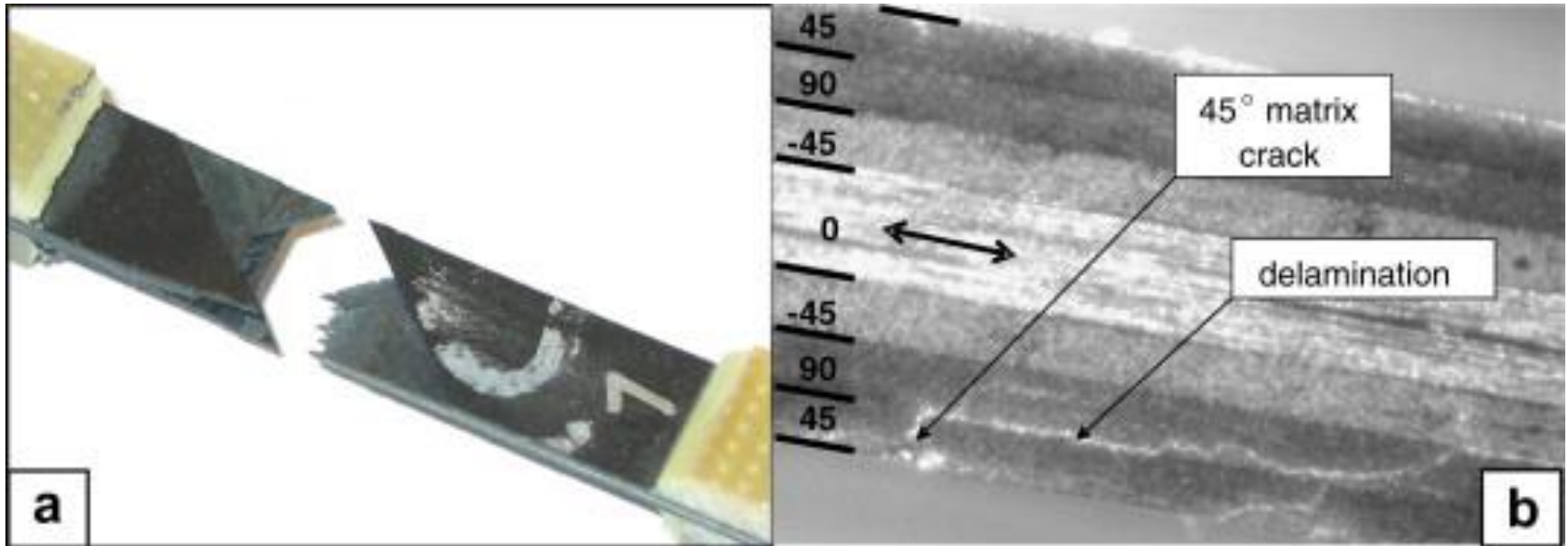
- Quasi-isotropic unnotched strength follows the same Weibull scaling line due to the same defect in the 0° plies.



Xu X et al. *Composite Part A*. 2016

Relating QI Strength to UD Strength

- Edge delamination caused stress concentration in 0° plies near end tabs, leading to premature failure
- If premature failure occurs, QI strength cannot be related to UD strength.



Wisnom MR et al. *Composite Structures*. 2008

Predicting QI Strength from UD Strength

- If premature failure is avoided by not using end tabs, QI strength is simply controlled by the same defect in the 0° plies.
- QI strength can be predicted using UD strength using Classical Laminate Theory.

Gauge length (mm)	QI test results (MPa) (C.V., %)	Predicted strength from UD (MPa)	Difference (%)
63.5	998 (2.0)	1012	1.4
127.0	990 (1.5)	995	0.5
254.0	964 (2.7)	979	1.5

Xu X et al. *Composite Part A*. 2016





Dr Xiaodong Xu
xiaodong.xu@uwe.ac.uk

Thank you

Reference:

Xu X, Wisnom MR, Chang K, Hallett SR. Unification of strength scaling between unidirectional, quasi-isotropic, and notched carbon/epoxy laminates. Compos Pt A-Appl Sci Manuf. 2016;90:296-305. <https://doi.org/10.1016/j.compositesa.2016.07.019>

