

KU LEUVEN



Model validation of the hybrid effect in carbon/glass hybrid composites

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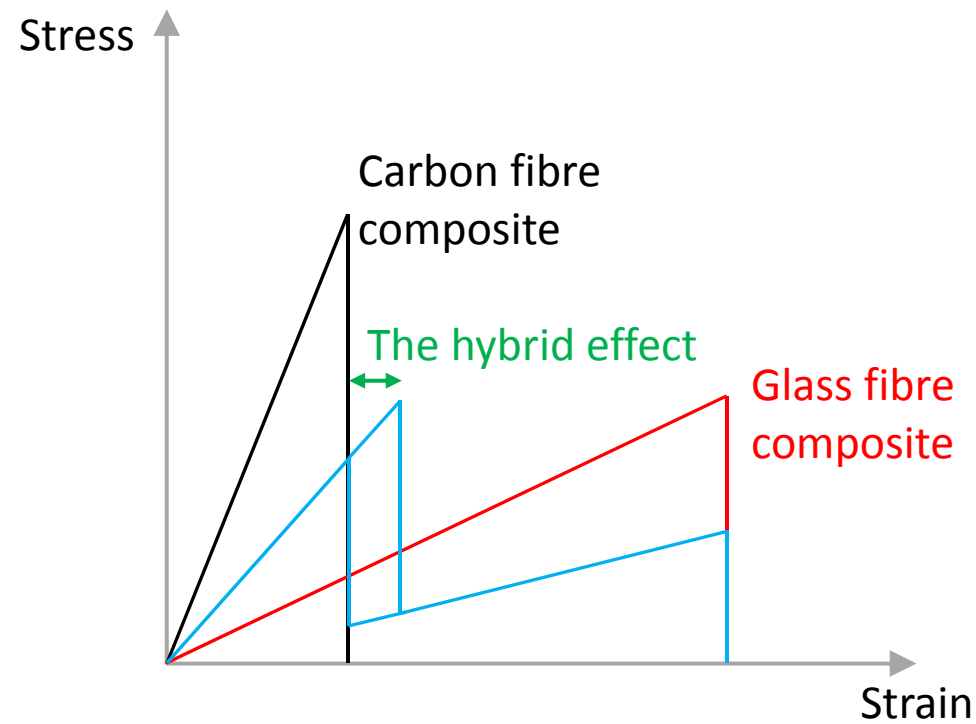
What is the failure strain
of a carbon fibre composite?

At which gauge length?

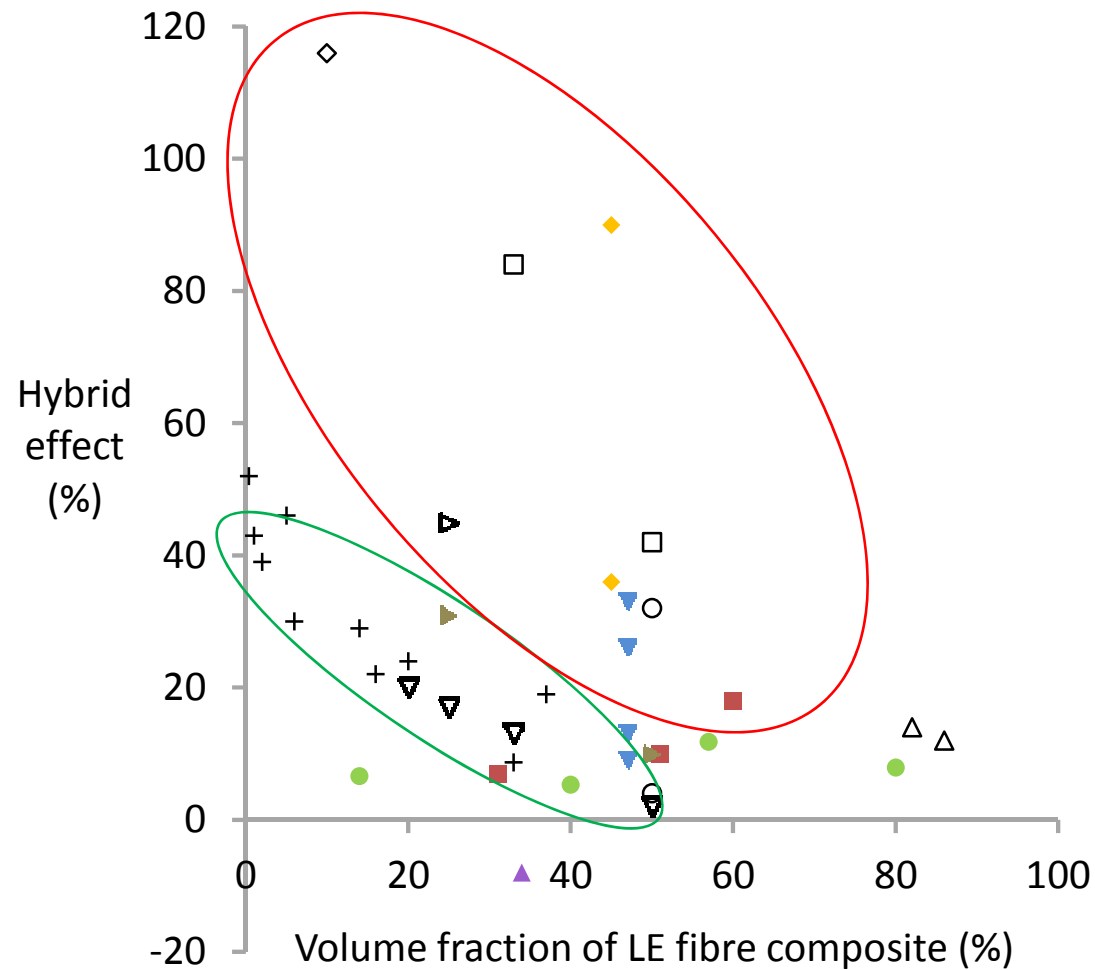
In which matrix?

Hybridised with which fibre?

The hybrid effect delays the failure of carbon fibre composites



The hybrid effect was found by many authors but not all data is trustworthy



Measuring failure strains is challenging

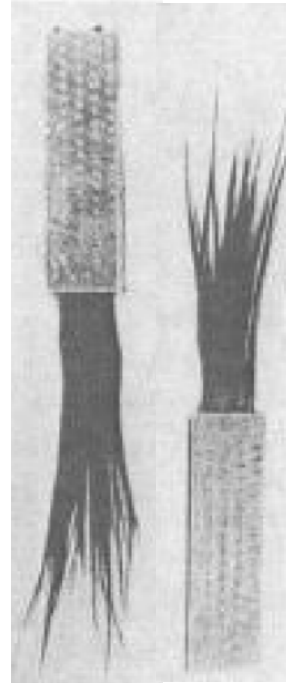
Fuwa et al. (1975)

Tensile tests

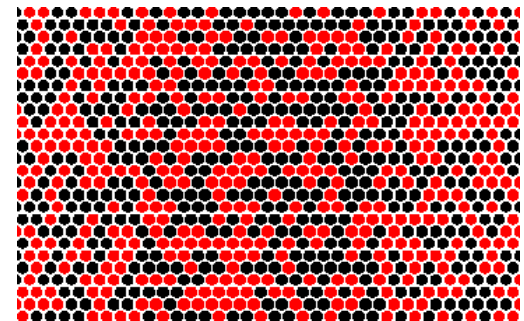
Stress concentrations at grips
Underestimation

UD composites

Transverse direction weak
Splitting
Explosive failure



Well comingled hybrid yarns not available



Predicting the hybrid effect is challenging

Three reasons

Delay in fracture propagation

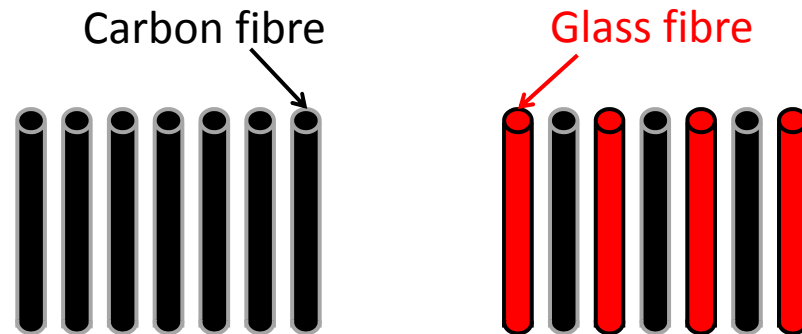
Residual stresses

Dynamic stress concentrations

Zweiben's model (1977)

126% predicted

31% and 83% measured



Not much progress afterwards

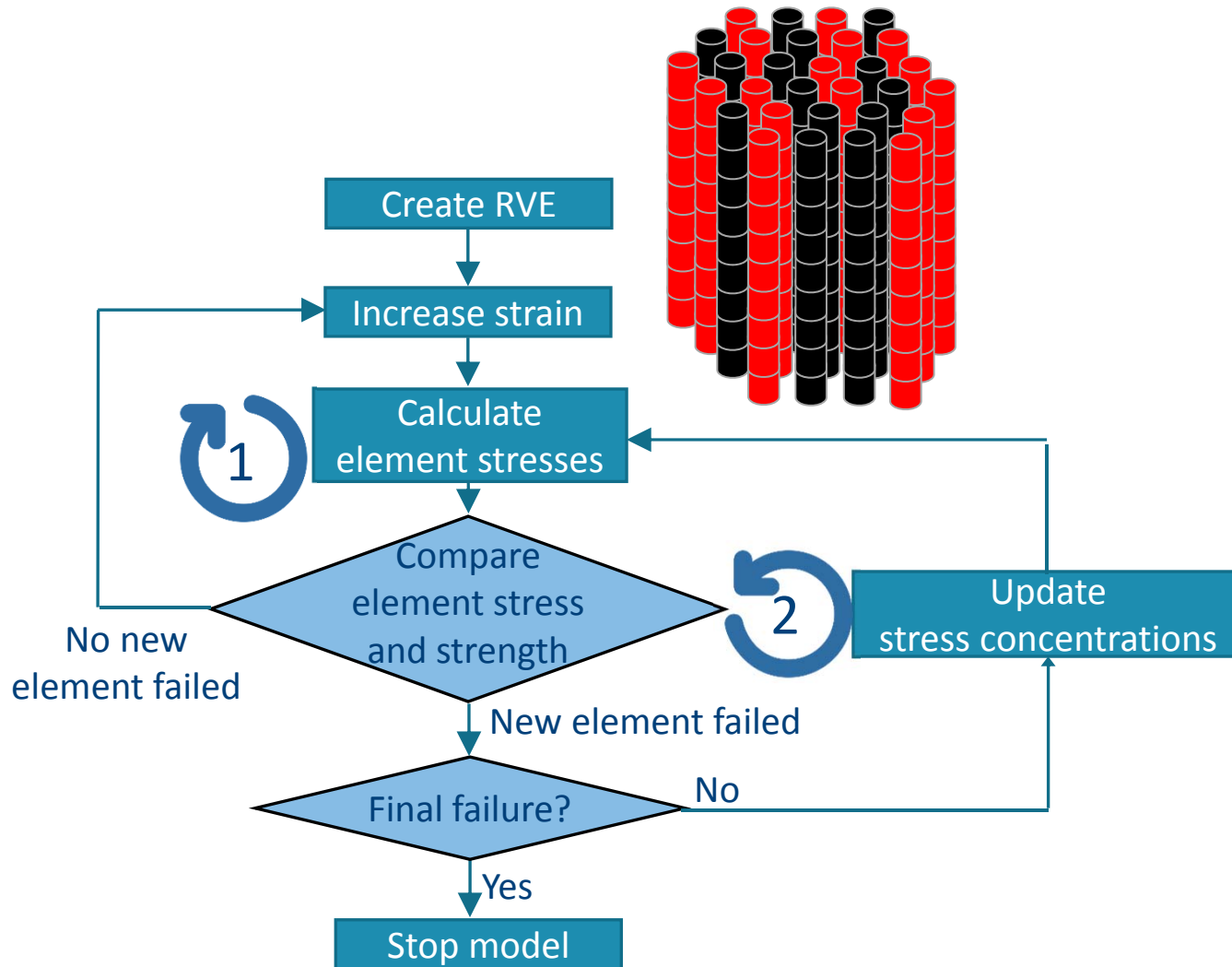
We can't measure it
We can't predict it

How to solve this?

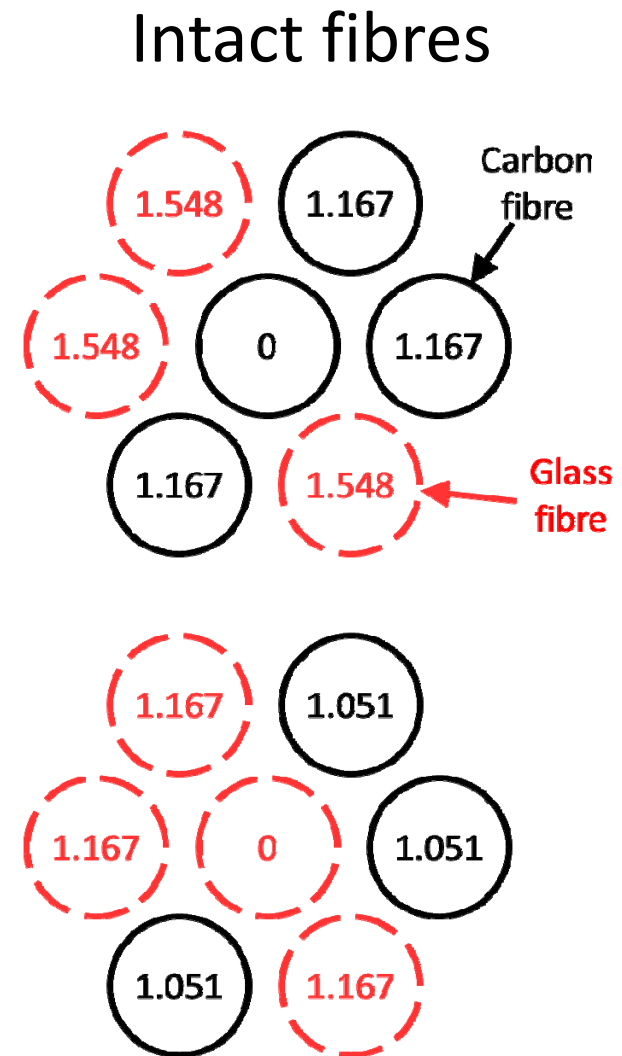
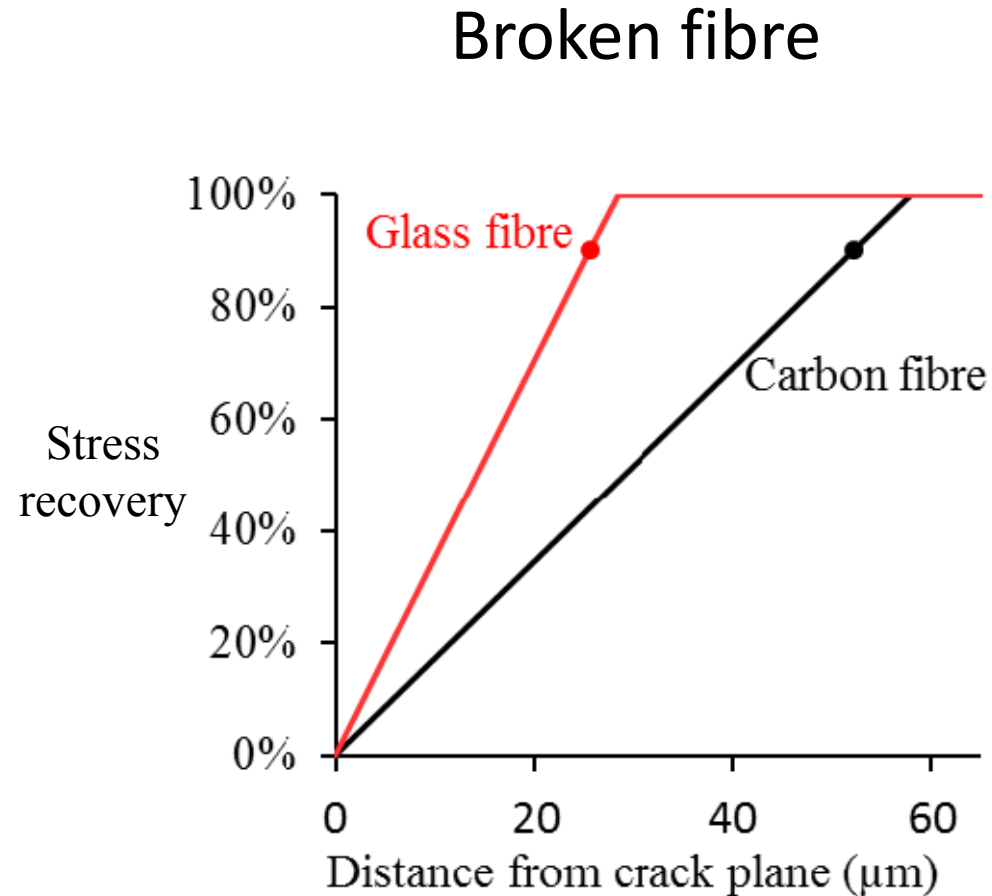
Comingled yarns not available
Mechanisms are understood

Can models lead the way?

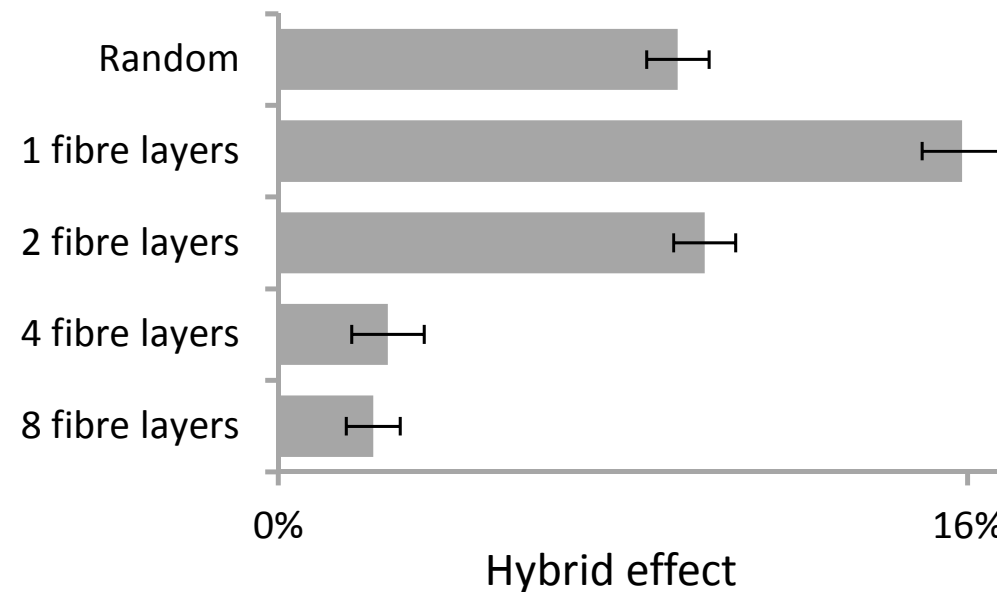
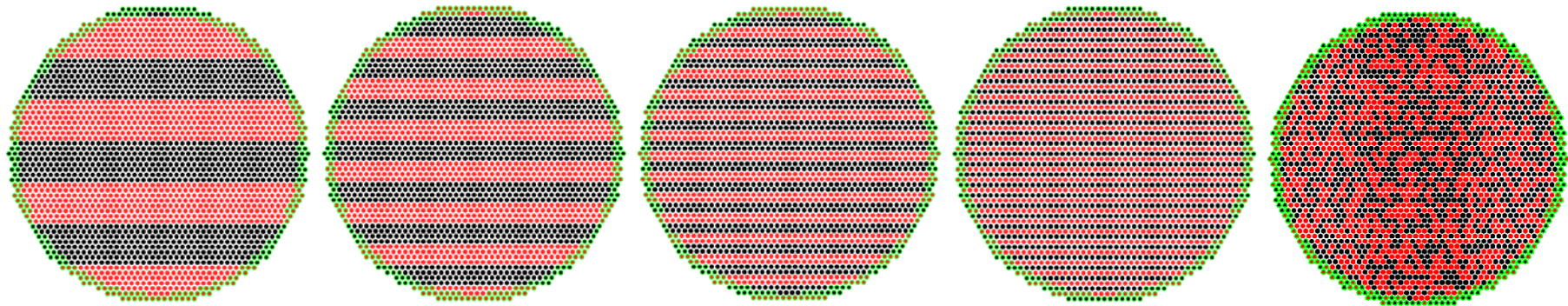
Traditional modelling scheme



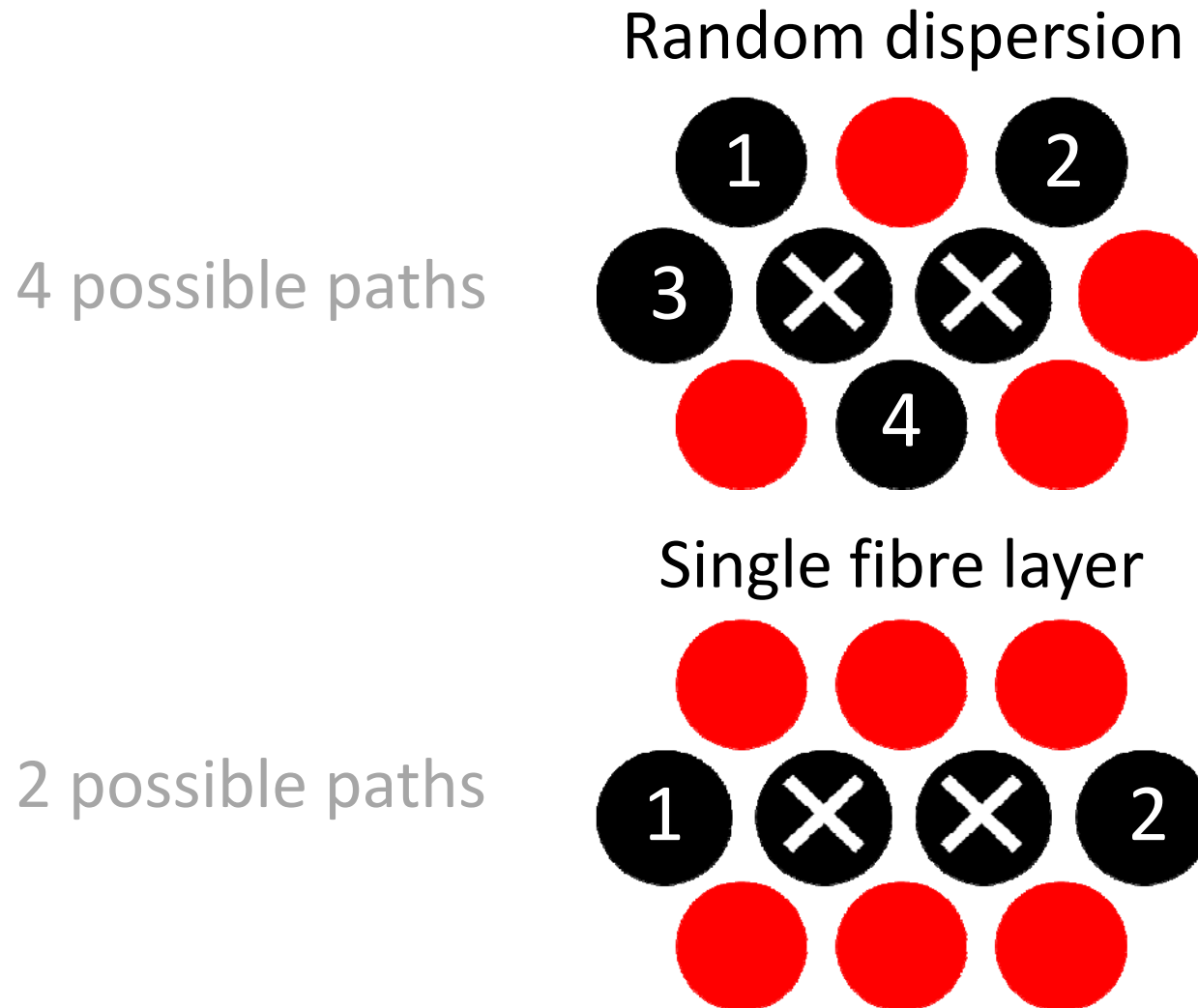
A simplified stress redistribution



Layered hybrids show a larger hybrid effect than comingled hybrids



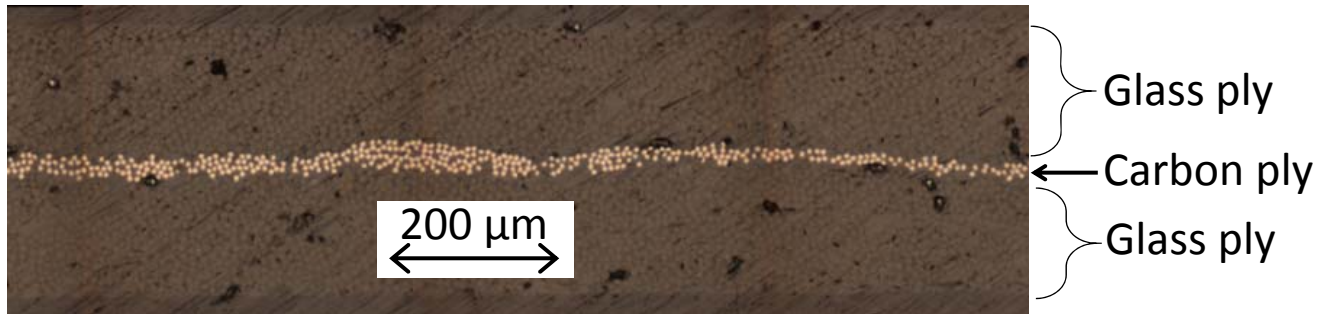
A single fibre layered hybrid reduces the number of crack paths



Thin ply composites facilitate measuring the hybrid composites

Thinnest plies

25-30 μm



4 layups

1-4 thin carbon fibre plies



Fitting model parameters to the 4 ply hybrid

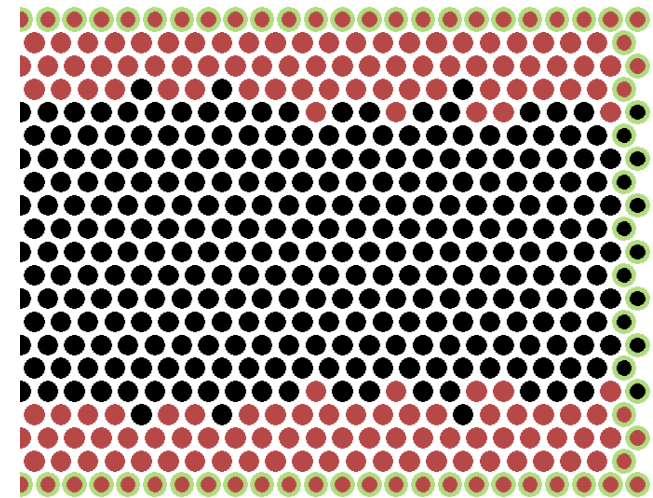
Input parameters

Data sheets or measured
Estimated

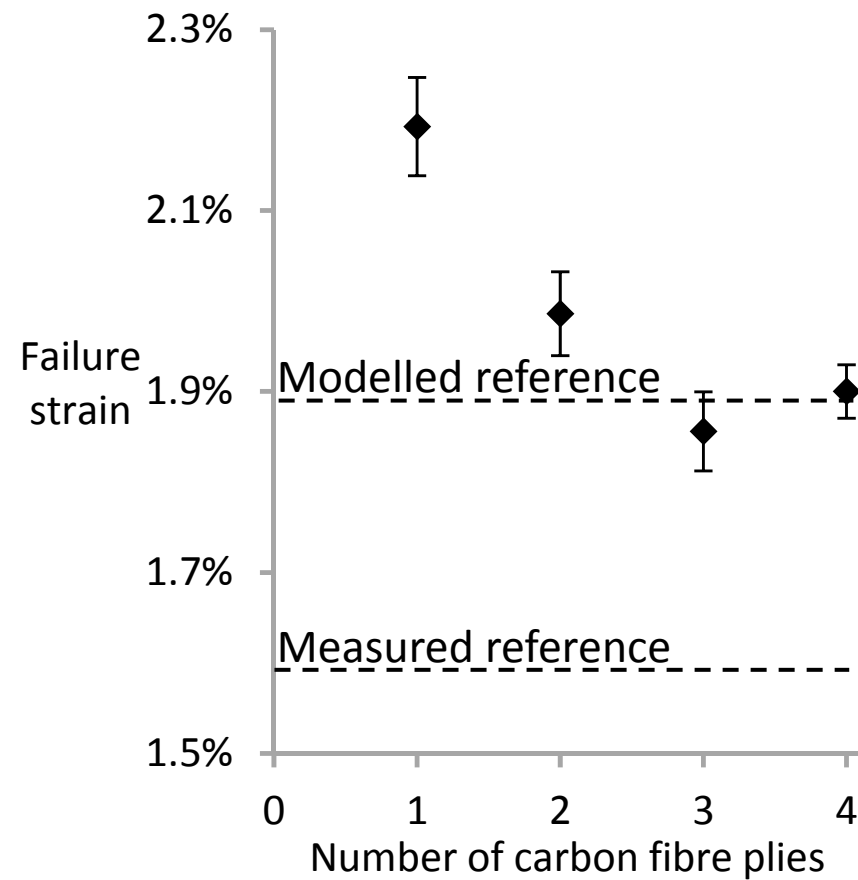
Weibull distribution of carbon fibre

$$m = 5$$

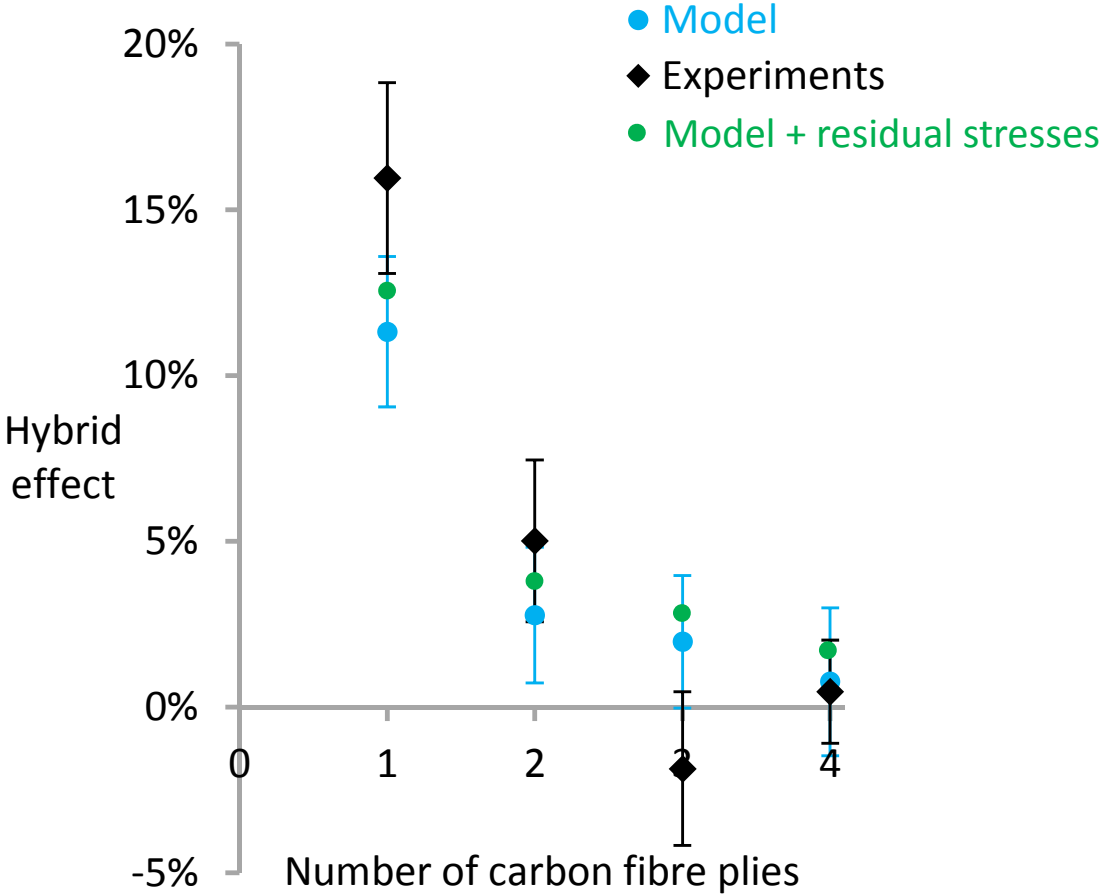
$$\sigma_0 = 3107 \text{MPa}$$



More reliable measurements lead to excellent agreement



Hybrid effects of up to 16%



Conclusions

The hybrid effect is real

Can be measured

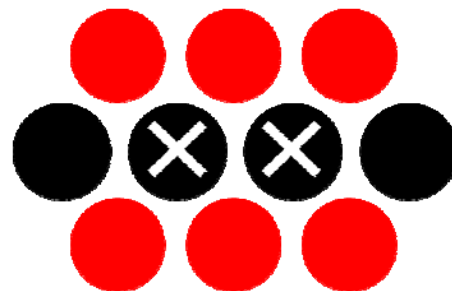
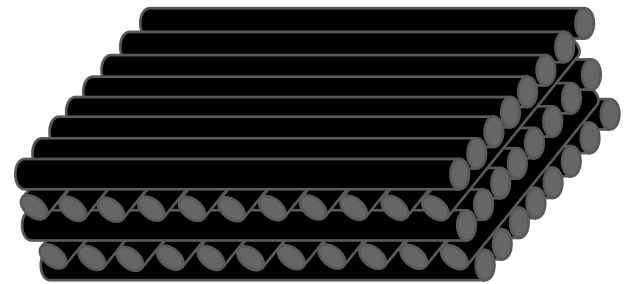
Can be predicted

Parametric study to maximise hybrid effect

Thin ply composites

Superior damage resistance

But: also hybrid effects!





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