Effect of viscoplasticity of the epoxy matrix on long-term stress redistribution around fibre breaks in a composite subjected to high static tensile load

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The wide-spread opinion persists that epoxy matrices behave in a purely brittle manner. Their plastic behaviour is commonly neglected for modelling of composites. Recent results [1], however, show the highly strain-dependent plastic behaviour of epoxy and suggest that their creep behaviour is important for the time-dependent failure of composites. The creep strain development was therefore characterized for a commercial epoxy resin system (North Thin Ply Technology 736LT).

These measurements were then plugged into a micro-mechanical finite element model. This model represented a standard composite microstructure consisting of T700 carbon fibres at a 50% volume fraction and was used to assess the time-dependent effect of stress redistribution around a fibre break. As the shear stresses in the matrix went down over time, the stress transfer region spreads out in fibre direction, which effectively lowers the stress concentration in the break plane but increases the effective overload in the longitudinal direction.

The results of the modelled representative volume element can be translated into a time-dependent local load sharing approximation, which is used as input data for the fibre break model from Swolfs et al. [2]. The advanced fibre break model is able to determine the strength degradation over time of a unidirectional composite bundle exposed to high static tensile load. By studying the development of the degradation paired with the respective probability for a certain path, better lifetime predictions for continuously loaded components can be made.

Modelling predictions are intended to be verified with the help of Synchrotron Computed Tomography at the submicron scale by holding a specimen at a constant displacement. The analysis of the scan data is still ongoing.

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