Degradation of thermo-elastic properties of non-uniformly composite laminates
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During the service life composite laminates undergo complex combinations of thermal and mechanical loading leading to microdamage accumulation in the plies. The most common damage mode is intralaminar cracking in layers. These cracks are reducing the thermo-elastic properties of laminates. A model called GLOB-LOC model was developed in [1,2] to calculate these properties for any given damage state. This analytical calculation scheme is exact if the input information is exact. However, the expressions contain two important approximate parameters which are obtained summarizing/fitting parametric analyzes results using FEM. These parameters are proportional to the average stress state between cracks which governs the stiffness reduction of the laminate and have the physical meaning of average opening displacement (COD) and average sliding displacement (CSD) of a crack.

Using this relationship analytical shear lag and Hashin’s models [3], developed for axial modulus, can be applied for calculating both thermal expansion coefficients, in-plane moduli and Poisson’s ratios of damaged laminates. The approach is evaluated using FEM and it shown that the accuracy is rather similar as in axial modulus calculation.

Most of the existing models are based on assumption that the crack distribution in the layer is uniform: the same distance between all cracks. Since optical observations show that it is not true, we present FEM simulation results to evaluate the effect of non-uniform crack distribution on elastic properties of RVE showing that the differences may be rather large.

A “double-periodic” approach presented to calculate the COD of a crack in a non-uniform case as the average of two solutions for periodic crack systems is very accurate for cracks in internal layers, whereas for high crack density in surface layers it underestimates the modulus reduction.

REFERENCES