Damage Accumulation and Stiffness Degradation in Composite Laminate

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Abstract:

By definition, a material which has two or more distinct phases or constituents can be regarded as a composite material. These materials are normally classified into two main types, particle and fiber reinforced composites. This classification is based on the geometry of the reinforcement where the particle is approximately equiaxed and the fiber is characterized by its length being much larger than its cross-sectional dimensions.
In general, composite materials have excellent specific properties. With specific we mean low weight and high stiffness. Hence, the most important area of usage for high performance composites is aerospace applications.

When a composite is loaded in tension with increasing load the composite will eventually fail (macroscopically). The failure is preceded by the initiation and evolution of microdamage. There are different microdamage (crack) modes. A part of the matrix can fail, fibers can fail, and there can be fiber/matrix interface debonding. Due to this kind of microdamage a composite undergoes stiffness reduction when loaded in tension. In other words, the elastic modulus in the loading direction will decrease.

The degradation of the elastic properties of these materials is due to two parameters: the crack face opening displacement COD and the crack face sliding displacement CSD. The main of this paper is to measure these parameters for different lay-up.
The displacement field on the edges of a $[0, 70_4, -70_4]_s$ GF/EP laminate specimens with multiple transverse cracks is visualized and analyzed on dependence of the applied mechanical load by using ESPI (Electronic Speckle Pattern Interferometry).
The different displacement profiles along the tensile-axis are drawn along the specimen edges at several distances from the mid-plane corresponding to the different plies.
The FEM was used to investigate the evolution of the COD by changing material properties.

Keywords

A. Laminates; B. Transverse cracking, B. Interaction; C. Damage mechanics; D. ESPI measurement.