Development of a Micro-Crack Toughening Mechanism for Unidirectional Composite Plates by using Peridynamics

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Room 2
Tuesday
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14h20

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Composite structures serve as primary structural components in today's engineering applications because of their superior tensile stiffness and rigidity as well as low weight to stiffness ratios. However, the brittle nature of its matrix constituent makes composites structures prone to any damage occurrence, leading to rapid fracture propagation through the structure. The unexpected failure of such a critical component of a composite structure can cause the entire fiber-matrix system to become completely useless. Albeit traditionally being overdesigned to avoid any unexpected mechanical failure, these structures cannot be often responsive to the damage propagation after the initiation of a small failure/defect. To overcome these damage-propagation issues, in this study, a novel toughening enhancement model is proposed for unidirectional composites. The toughening mechanism is established by introducing the so-called micro defects/cracks for increasing the toughness of matrix constituent of the composite structure. Mechanical simulations are performed utilizing a non-local continuum formulation known as bond-based Peridynamics (PD). The PD formulation facilitates the modeling of material discontinuities such as complex crack/defects formations with an arbitrary size, orientation, and location features in composite structures. Here the toughening enhancement models are established by allocating various micro-crack formations in three different fiber orientations (0, 45, 90 degrees) of UD composite plates. The toughening effects of micro-crack clusters are thoroughly analyzed by making comprehensive comparisons on the propagation speed of an initially introduced macro-crack. As a result, unique micro-crack distributions are found for each fiber orientation of the UD composite, providing an augmented toughness to the brittle composite materials.

Failure simulation of four point bending CFRP laminate specimen including wrinkles

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The influence of manufacturing defects in laminated composites is an major field of research according to their detrimental effects on the residual strength of the structure [1]. Among the different types of defects, wrinkling and waviness are perhaps one of the most common and detrimental, especially under compression. Here the term "waviness" is used to describe in-plane misalignment of fibers and the term "wrinkling" refers to out-of-plane misalignment of fibers. In the literature, wrinkling in a planar part is massively studied [2-3] but to our knowledge, less interest was paid to the influence of wrinkling present in the radius of a curved part. In this paper, a numerical study the influence of wrinkles contained in the radius of L-shape specimen tested under four-point bending tests is done. The used model called 'Discrete Ply Model' (DPM) and developed at Institut Clement Ader [4–6] a decade ago [4–6], which has already demonstrated its capability to give a good agreement between experimental results and simulation of four points bending tests without wrinkles [7]. Several specimens with different severities of wrinkling were manufactured. Concave moulds were used with two strategies of stacking. The first one consists classically to lay in the concave mould the different plies