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Homogenized models of failure of defected composite microstructures with contact effects

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The computation of the behavior of a composite material by recognizing explicitly microstructural evolution related to damage propagation, usually requires a large computational effort. To this end it is preferable to determine the mechanical response of a composite solid in terms of its homogenized properties [1].

In the present work the effects of microcrack onset and propagation along an a-priori unknown path on the homogenized response of elastic composite materials are investigated. A micro-mechanical approach based on homogenization techniques and fracture mechanics concepts is adopted and an original J-integral formulation is applied to composite micro-structures on the basis of the results obtained in [2, 3]. The crack propagation process is driven by the maximum energy release rate criterion, which is used to predict incremental changes in crack path. The adopted propagation condition includes the competition between kinking or straight-ahead interface crack propagation under mixed-mode loading ([4]). A coupled stress and energy criterion ([5]) is adopted to predict crack initiation within an originally undamaged microconstituents or at a bi-material interface. To this aim a novel strategy for quasi-automatic simulation of propagation of arbitrary cracks in two-dimensional finite element models has been implemented.

With reference to cellular and fiber-reinforced microstructures, accurate non-linear macroscopic constitutive laws are obtained for several prescribed macro-strain paths by means of a finite element formulation. Changes in micro-structural configuration owing to crack growth and crack faces contact are accounted and the micro-to-macro transition is obtained for boundary conditions of periodic fluctuations and anti-periodic tractions. The proposed model may be useful for the design and evaluation of composite structures due to its capability of predicting failure due to micro-crack initiation and propagation.

Keywords: Crack onset, Mixed mode crack propagation, Homogenization, Periodic composites, Finite elements, Contact

References

[1] F.G. Yuan, N.J. Pagano, X. Cai, "Elastic Moduli of brittle matrix composites with interfacial debonding", *International Journal of Solids and Structures*, 34 (2), 177-201, 1997.

[2] D. Bruno, F. Greco, P. Lonetti, P. Nevone Blasi, "Influence of micro-cracking and contact on the effective properties of composites materials", *Simulation Modelling Practice and Theory*, 16 (8), 861-884, 2008.

[3] F. Greco "Homogenized mechanical behavior of composite micro-structures including micro-cracking and contact evolution", *Engineering Fracture Mechanics*, 76, 182-208, 2009.

[4] J. W. Hutchinson, Z. Suo, "Mixed mode cracking in layered materials", *Advances in Applied Mechanics*, Academic Press, 29, 64-187, 1992.

[5] D. Leguillon, "Strength or toughness? A criterion for crack onset at a notch", *European Journal of Mechanics A/Solids*, 21, 61-72, 2002.