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Numerical prediction of fiber mechanical properties considering random microstructures using inverse analysis with quasi-analytical gradients. (English) Zbl 1410.74090

Appl. Math. Comput. 273, 201-216 (2016).

Summary: An efficient and robust numerical scheme is reported that can inversely evaluate the elastic properties of fibers in unidirectional composites from the material properties of matrices and composite laminae. Considering the effect of microstructures such as random fiber arrangement, a set of finite element meshes are employed to represent the interaction between fiber and matrix. A lamina-scale cost function comprising the difference between the measured elastic properties, and the computed elastic properties of a unidirectional lamina is minimized to evaluate fiber properties. In the minimization process, quasi-analytical gradients derived from prediction formulae, such as the Chamis or Halpin-Tsai models, are adopted to greatly reduce the computation cost. To verify the proposed scheme in terms of accuracy, efficiency, and robustness, the elastic properties of T650-35 fiber in a T650-35/PMR-15 lamina are evaluated with various representative volume elements containing randomly distributed fibers and voids. The evaluation results obtained by the proposed scheme are compared with results in the literature, and the effects of microstructures are discussed.

MSC:

74S30	Other numerical methods in solid mechanics (MSC2010)
65K10	Numerical optimization and variational techniques
74M25	Micromechanics of solids
82D80	Statistical mechanics of nanostructures and nanoparticles

Keywords:

fiber elastic properties; unidirectional composites; microstructures; random fiber arrangement; random void distribution; quasi-analytical gradients

Software:

Matlab; ABAQUS

Full Text: DOI

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