
An Instability Analysis for Long Fiber Reinforced Composite with Asymptotic Numerical Method

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Résumé

The fiber microbuckling in long fiber composites may lead to the compressive failure of the macrostructure. To study such a multiscale problem, direct simulation is limited due to the expensive computation cost and difficulties in selecting non-linear calculation paths, because there often exists a lot of bifurcation points around the useful one. This work is to propose an efficient multiscale model for accurately simulating and analyzing the instability phenomena of long fiber reinforced materials. The multi-level finite element method (FE2), see Nezamabadi et al. (2009), is adopted to realize the real-time interaction between macro and microscopic levels: the macroscopic constitutive law is homogenized on the Representative Volume Element (RVE), and the microscopic deformation gradient is transferred from the associated macroscopic integration point. However, the total computation cost may be still very high because the RVE on each macroscopic integration point needs a sufficient fine mesh to simulate the microbuckling of long fibers. Thus, a Fourier related model, see Liu et al. (2012), is developed on the RVE to transform the fast varying microscopic unknowns into a series of slowly varying ones which only requires remarkably reduced meshes. In addition, the proposed RVE model allows one to control non-linear calculation paths easily by choosing the wavelength of the buckled fiber. The developed non-linear multiscale model is solved by the Asymptotic Numerical Method (ANM), see Cochelin et al. (1994), which is less time

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consuming and more robust than the classical iterative methods such as the Newton-Raphson or the arc-length (Riks) method. This path following technique benefits from its two main advantages: 1) the step length is self-adapted in non-linear calculations; 2) the stiffness matrix only requires once inverse in each incremental step. The established multiscale model yields accurate results with a significantly improved computational efficiency.

Mots-Clés: Asymptotic Numerical Method, Long fiber reinforced composites, Instabilities, Fourier series, Multiscale.