A new theoretical model of the quasistatic single-fiber pullout problem: Analysis of stress field

A new theoretical model is developed in order to predict the stress transfer during the quasistatic single-fibre pullout process. The theoretical approach retains all relevant stress and strain components, and satisfies exactly the interfacial continuity conditions and all the stress boundary conditions. For both matrix and fibre, the equilibrium equations along radial direction are satisfied strictly, while the equilibrium equations along axial direction are satisfied in the integral forms. Three normal stress-strain relationships are strictly satisfied, while the radial displacement gradient with respect to the axial direction is neglected for shear stress-strain relationship. The general solutions of the axial and radial displacements in both fibre and matrix are obtained in explicit forms. In the debonded region, a modified Coulomb's friction law, in which the frictional coefficient is a decreasing function of pullout rate, is applied to determine the interfacial frictional stress. The new analytical approach allows performing more detail theoretical analysis on the stress transfer between fibre and matrix, and distributions of stress, strain and displacement in fibre and matrix. Numerical results of the stress distributions, in both fully bonded region and fully debonded region, are presented for a typical glass/epoxy composite system with different fibre volume fraction and model length. In fully bonded region, the theoretical results from present model are more accurate compared with those from Lame solution, and agree well with the results from finite element model. In fully debonded region, present model can predict the initial pullout stress under different geometrical conditions and static friction coefficient, also can predict more reasonable stress distribution than Lame solution. © 2013 Elsevier Ltd. All rights reserved.