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Analysis of cracked laminates: a variational approach

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Abstract

Cross-ply ($[0Â^\circ_m, 90Â^\circ_n]_s$) laminates which contain distributions of intralaminar cracks within the 90Â° ply are analyzed by variational methods for tensile and for shear membrane loading. Admissible stress systems which satisfy equilibrium and all boundary and interface conditions are constructed and the principle of minimum complementary energy is employed to find an optimal approximation. This yields approximate stress fields and rigorous lower bounds for stiffnesses. The analysis allows for crack interaction and statistical distribution of cracks. Results for Young's modulus are in perfect agreement with experimental data. Young's modulus and shear modulus results approach definite limits for large crack density. Typical stress variations are presented for glass/epoxy and for graphite/epoxy laminates and their implications for the progressive damage and failure process of laminates are discussed.

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