POTENTIAL OF SIMPLE ANALYSIS BASED ON MINIMIZATION OF COMPLEMENTARY ENERGY TO PREDICT SHEAR MODULUS IN LAMINATES WITH TRANSVERSE CRACKS

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In laminated composite materials, many different kinds of micro-damage modes may evolve without leading to final failure, causing however stiffness reduction. The most common damage mode and the one examined in this work is intralaminar cracks in transverse layers. These cracks can occur when the composite structure is subjected to mechanical and/or thermal loading and eventually lead to degradation of thermo-elastic properties. In the present work, the shear modulus reduction due to transverse cracking is studied.
Mathematical models exist in literature, but they only cover the simple case of crossply laminates. The in-plane shear modulus of a damaged laminate is only considered in a few cases. In the current work, the shear modulus reduction in cross-plies will be analysed based on the minimization of complementary energy principle. According to this principle the most accurate between all "admissible" stress states, is the one which gives the lowest value of the complementary energy. Hashin in [1] investigated the in-plane shear modulus reduction of cross-ply laminates with cracks in inside 90-layer using a this variational approach. However, the stress relations used by Hashin cannot give accurate solutions since it is assumed that the stresses in the transverse layers do not depend on the z coordinate. In this study, a more detailed and accurate approach for stress estimation is followed. The results for complementary energy are then compared with the respective from literature and finally an expression for shear modulus degradation is derived.

REFERENCES

1. Hashin Z. Analysis of cracked laminates: a variational approach. Mech of Mater, North-Holland 1985;4:121-136