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A cumulative damage model to predict the fatigue life of composite laminates including the effect of a fibre-matrix interphase

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Abstract

Recent experimental efforts have established the significance of the fibre-matrix interface /interphase in the long-term behaviour of polymeric composites. Results indicate that small alterations at the interface level could translate into orders-of-magnitude changes in fatigue life. However, there is no model currently available in the literature to predict these changes. In this paper, a micromechanics model that includes the effects of the fibre-matrix interface is used in a simple cumulative damage scheme to predict the tensile fatigue behaviour of composite laminates. A new parameter called the â€˜efficiency of the interfaceâ€™ is used to model the degradation of the in terface under fatigue loading. A rate equation that describes the changes in interfacial efficiency as a function of cycles is estimated using experimentally determined stiffness reduction

as a function of cycles is estimated using experimentally determined stiffness reduction data. The influence of this interfacial efficiency parameter on the tensile strength of unidirectional laminates is assessed using a micromechanics model. The effect of damage on the stiffness of the laminate is estimated by solving a boundary value problem associated with the particular damage mode (e.g. transverse matrix cracking). The fatigue life of the laminate is estimated by considering changes in stiffness due to creep and damage in the subcritical elements, and changes in strength associated with the critical element (0Â° ply). The influence of a fibre-matrix interface is included in the model by considering the degradation in the interface (interfacial efficiency) under fatigue loading. Changes in the interface property are used in the micromechanics model to estimate changes in the in-situ tensile strength of the 0Â° ply. The stress state and the strength of the 0Â° ply, calculated including the effects of damage, are then used in a maximum strain failure criterion to determine the fatigue life of the laminate. Predictions from this model are compared with experimental data. The predicted fatigue life and failure modes agree very well with the experimental data.

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Keywords

fatigue; interface; damage; life prediction; composite laminate; micromechanics

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