MODELLING OF MULTI-LAYER DAMAGE IN COMPOSITE LAMINATES UNDER STATIC OR FATIGUE LOADING

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ABSTRACT

Delamination is a commonly observed failure mode in fibre-reinforced composite laminates subjected to static or fatigue tensile loading. Its initiation is often triggered by matrix cracks, i.e. cracks in the resin running parallel to the fibres in the off-axis ply of the laminate, which result in high interlaminar stresses at the ply interface.

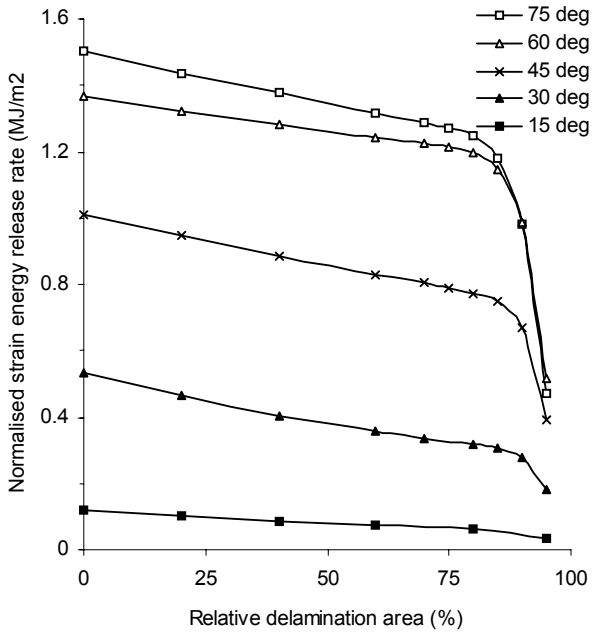

Figure 1. Normalised strain energy release rate $G^{ld}/\bar{\varepsilon}_{xx}^2$ vs relative delamination area for $[0_2/\theta_2/-\theta_2]_s$ AS4/3506-1 laminates.

In the present paper, local delaminations growing uniformly from the tips of matrix cracks in the ϕ_n-layer of a general symmetric $[\phi_1/\phi_2/\ldots/\phi_n]_s$ laminate subjected to in-plane tensile loading are analysed. The strain energy release rate associated with such delaminations, G^{ld}, is predicted analytically using the Equivalent Constraint Model of the damaged laminate [1, 2]. Stress field in the damaged ply is determined from the analysis of a representative segment containing one crack and two crack tip delaminations by means of a 2-D shear lag method.

A closed-form expression for the strain energy release rate is derived, representing it as a linear function of the first partial derivatives of the degraded stiffness properties of the damaged ϕ_n-layer with respect to the delamination area. The effect of matrix cracking and delamination on the laminate stiffness properties is also determined.

1. Zhang, J., Soutis, C. and Fan, J. (1994) Strain energy release rate associated with local delamination in cracked composite laminates. *Composites,* 25(9): 851-862
2. Kashtalyan, M and Soutis (2001) Strain energy release rate for off-axis ply cracking in laminated composites. *Int J fracture*, **112**, L3-L8, 2001.