An advanced fatigue cohesive model and application to defect cases

Bing Zhang and Stephen Hallett

Interlaminar failure (delamination) is recognised as a main cause of catastrophic failure in composite laminates. Cyclically loading on composite laminates can induce interlaminar failure at a much lower load than under static loading. This project develops an advanced finite-element cohesive model that can be employed to evaluate the delamination resistance of a composite structure under fatigue loading. The numerical modelling technique is then applied to predict fatigue damage in laminates with and without defects (cut-ply, wrinkle, and wrinkle & cut-ply).

**Fatigue cohesive model**

Virtual fatigue loading based on a global load envelope

Algorithm for multi-integration elements. Elem. 1 (failed) Elem. 2 (crack-tip)

\[
G_{\text{Avg}} = \frac{(G_{IP1} + G_{IP2} + G_{IP3} + G_{IP4})}{4}
\]

\[
G_{\text{max}} = \max(G_{\text{Avg}1}, G_{\text{Avg}2})
\]

\[
\frac{da}{dN} = f(G_{\text{max}}, cI, mI, cII, mII)
\]

Nomenclature

- \( G \): Energy release rate
- \( a \): Crack length
- \( f_N \): Pseudo frequency
- \( N \): Number of cycles
- \( c \): Paris law constant
- \( m \): Paris law exponent
- \( \sigma \): Interface traction
- \( \delta \): Interface relative displacement
- \( P_{\text{max}} \): Fatigue severity

Bilinear cohesive static/fatigue law

Estimate of fatigue characteristic length by the gradient of ERR

A fast and effective algorithm to search element neighbours by chopping the model into small chunks

**Application to defect cases**

A ply-level mesh allowing matrix cracking prediction in four ply orientations

Pristine, cut-ply, wrinkle and wrinkle & cut-ply FE models

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