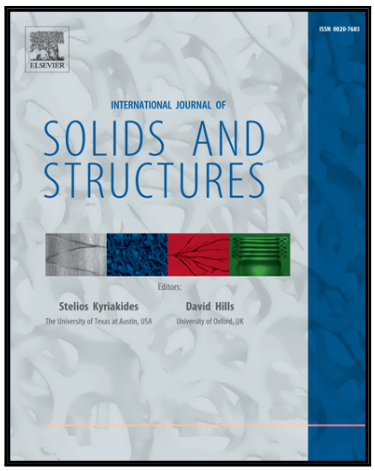

Mixed-mode fracture in open-hole composite plates of finite-width: an asymptotic coupled stress and energy approach

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Mixed-mode fracture in open-hole composite plates of finite-width: an asymptotic coupled stress and energy approach

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Abstract

In the present work, brittle failure of finite-width composite plates containing a circular hole under uniaxial tension loading is investigated using a coupled stress and energy criterion within the framework of finite fracture mechanics. Depending on the material anisotropy, the onsets of symmetric and antisymmetric crack patterns are investigated considering mixed-mode fracture. In order to provide an efficient finite fracture mechanics analysis, a semi-analytical approach is proposed combining the method of complex potentials with a two-scale asymptotic solution procedure. Within the asymptotic framework, higher-order terms and the application of Padé approximation are implemented allowing for an extended applicability of the asymptotic solutions. In addition, full-numerical analyses are performed and the accuracy of the asymptotic approach, in particular with regard to the finite-width, is thoroughly examined. The effects of hole size and fibre orientation on the plate's effective strength are studied using the proposed finite fracture mechanics approach and theoretical strength predictions are compared to experimental results from literature.

Keywords: Mixed-mode fracture, Finite fracture mechanics, Crack initiation, Matched asymptotic expansions

1. Introduction

Joining individual components in engineering structures induces open-holes and cut-outs that can significantly affect the structural integrity. Premature failure of the structure typically originates from such stress raisers. This is, in particular, a major concern regarding open-hole composite plates of finite-width under uniaxial tension. Whereas the dimensionless stress concentration factor for infinite isotropic open-hole plates attains the well known value of three following Kirsch's solution (Kirsch, 1898), it's value significantly depends on the composite layup and the finite-width in case of open-hole composite plates. Hence, a detailed understanding of the underlying failure processes is crucial for a reliable failure assessment at these stress concentrations.

Almost a hundred years ago, non-local assessment concepts have been suggested and successfully applied to structures exhibiting stress concentrations. A non-local evaluation of either the stresses at a certain distance away from the stress raiser (Neuber, 2000; Peterson and Wahl, 1936; Whitney and Nuismer, 1974) or fracture mechanics

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