

Finite fracture mechanics prediction of debonding failure in multilayer configurations

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Abstract

In mechanical engineering, aerospace engineering and civil engineering there are many situations where multilayer configurations occur. This can, for instance, be the case in laminate structures, in adhesive bondings or in local patch reinforcements. Under given mechanical or thermal loading due to the dissimilar material properties, typically stress concentrations will arise at the ends of the involved layers, which might lead to the onset of debonding cracks and a subsequent debonding failure. To assess such situations in the framework of linear elasticity theory, a closed-form analytical approach is suggested based on layerwise displacement representations that take singular stress concentrations into account. Such an approach appears to be much more effective and efficient than the commonly used polynomial series expansions of conventional multilayer theories. From the suggested displacement representation by means of the principle of minimum potential energy, an approximate closed-form description of the resultant deformation and stress distribution can be derived and validated by accompanying finite element calculations. In order to assess potential failure in the framework of finite fracture mechanics, debonding cracks of finite length are introduced and the corresponding incremental energy release is identified. Using the hybrid failure criterion suggested by Leguillon [1], it is possible to clearly conclude whether such debonding failure will happen in reality or not. By means of a corresponding optimization problem, also the minimal critical loading leading to failure can be determined. This is of high significance for the practical application.

Keywords:

Debonding initiation closed-form analysis finite fracture mechanics hybrid failure criterion

References:

[1] Dominique Leguillon: Strength or toughness? A criterion for crack onset at a notch. *European Journal of Mechanics –A/Solids* 21 (2002) 61-72.