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Crack path selection and toughening in multilayered joints

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Abstract

The deployment of advanced polymer-based composites in critical structural components requires further advancements in adhesive bonding solutions that offer superior mechanical performance. One strategy to increase the joint toughness involves maximizing plastic dissipation during crack growth. A conventional toughening strategy is to increase the adhesive thickness. Alternatively, incorporating a soft, compliant interlayer within the bondline can also potentially augment plastic dissipation. Nevertheless, the introduction of such an interlayer influences the crack trajectory, thereby affecting the overall joint toughness. The present study investigates two configurations: a single layer joint and a bilayer joint. In the bilayer one, a hard and a soft layer are inserted between two elastic adherends, as well as the reference single layer problem. A steady-state formulation is used with a traction separation law to characterize the failure process. Regarding the single layer joint, the focus is on the influence of plasticity on the crack path in a joint. The results are compared to those of Fleck et al. (1991) for elastic adhesive joints. It is found that plasticity influences the crack path if high plastic deformations take place in the joint and if the plastic zone size exceeds 1/10 of the adhesive thickness. Regarding the bilayer, the focus is on the impact of the interlayer properties on crack path selection and, subsequently, on the joint toughness. Large elastic and yield stress mismatches are found to maximize the joint toughness. In addition, the crack is found to often propagate towards the hard layer. Crack propagation in the hard layer can lead to plastic deformation in the soft compliant layer. To maximize the joint toughness, the height of the soft layers should ideally correspond to the plastic zone size, while the hard layer should be thin, regardless of the selected crack path. This motivates pursuing a strategy

for enhancing the toughness of adhesive joints and of other assemblies through the integration of compliant/soft interlayers near the crack propagation path.

Keywords:

Toughness Crack path Plasticity Multilayers