Fracture mechanics solutions for interfacial cracks between compressible thin layers and substrates

The decohesion of coatings, thin films, or layers used to protect or strengthen technological and structural components causes the loss of their functions. In this paper, analytical, computational, and semi-analytical 2D solutions are derived for the energy release rate and mode-mixity phase angle of an edge-delamination crack between a thin layer and an infinitely deep substrate. The thin layer is subjected to general edge loading: axial and shear forces and bending moment. The solutions are presented in terms of elementary crack tip loads and apply to a wide range of material combinations, with a large mismatch of the elastic constants (isotropic materials with Dundurs’ parameters −1 ≤ α ≤ 1 and −0.4 ≤ β ≤ 0.4). Results show that for stiff layers over soft substrates (α → 1), the effects of material compressibility are weak, and the assumption of substrate incompressibility is accurate; for other combinations, including soft layers over stiff substrates (α → −1), the effects may be relevant and problem specific. The solutions are applicable to edge- and buckling-delamination of thin layers bonded to thick substrates, to mixed-mode fracture characterization test methods, and as benchmark cases.

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