ABSTRACT

A quasi-static approximation has been widely used to model ultrasonic wave interactions at imperfect interfaces. To simulate the reduction of static stiffness of the overall structure due to compromised interfaces (micro-cracks or micro-disbonds) the compliance of an imperfect interface to a loading is represented by continuous, uniform distributions of interfacial springs. In this work, a representation by normal and transverse effective spring stiffnesses of an array of non-interacting penny shaped cracks at the interface between two dissimilar materials is obtained based on the classical fracture mechanics. The results obtained are useful in estimating the degree of disbonded area, which is critical in assessing the bond integrity and estimating the remaining life. Special care is taken to avoid crack surface interpenetration for transverse loading and the valid loading range is obtained to assure negligibility of crack surface interpenetration for all possible ranges of material combinations. For linear ultrasound applications, it is shown that the expression obtained for transverse springs can be used for most material combinations if the initial maximum crack opening displacement is more than $10^{-6}$ of the crack radius. The obtained expressions are applied to estimate the accuracy of approximate expressions obtained by rules of mixture and Hertzian-based effective moduli for the case of dissimilar materials from analysis of penny shaped cracks in a homogeneous material. It is shown that for most practical material combinations the error is below 5%. 