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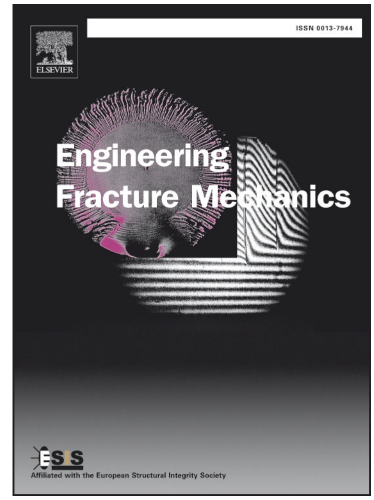

Cracks in heterogeneous materials with rotating constituents – Small and Intermediate scale Cosserat continua

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Cracks in heterogeneous materials with rotating constituents – Small and Intermediate scale Cosserat continua

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Abstract

Cosserat continuum modelling of crack propagation in particulate materials with microrotations and in layered materials with sliding requires the analysis of the Cosserat characteristic lengths in their relation with the characteristic length of the material microstructure. The Cosserat lengths that are of the order of the microstructural characteristic length should be set to zero to derive the main asymptotic terms. When all Cosserat characteristic lengths are of the microscopic length the obtained continuum is termed the *Small scale Cosserat continuum*. Cracks of Modes I, II, III have conventional stress singularity, as well as the moment stress singularity. Moment stresses can cause bending failure of the bonds connecting the grains in the particulate material or layers in the layered material. Cases are identified when the bending stress induced by moment stress singularity exceeds tensile stresses induced by the conventional stress singularity by an order of magnitude. Then the main mechanism of crack propagation is bending failure produced by the moment stress, which explains, in a unified fashion the often-observed in-plane propagation of cracks of the classical modes. Another interesting case is when some Cosserat characteristic lengths are large. This gives what we term the *Intermediate scale Cosserat continuum*. An example is given by layered material with sliding layers that keep full contact during sliding. In this case the crack normal to the layering also propagates by bending failure produced by the moment stress singularity.

Keywords: Characteristic length, Intermediate asymptotics, Particulate material, Sliding layers, Moment stress, Bending.

1 Introduction

The analysis and modelling of crack growth in heterogeneous materials presents a considerable challenge as the heterogeneities change the stress state in front of the crack tip and thus can locally change the direction of crack propagation especially when the material contains pre-existing cracks (e.g., Blackburn, et al., 1996; Ayatollahi, et al., 2002). This may lead to roughness of the crack surface even in its quasistatic growth (e.g., Amitrano and Schmittbuh, 2002). Furthermore, the

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