Author's Accepted Manuscript

Effective toughness of heterogeneous media

M.Z. Hossain, C.-J. Hsueh, B. Bourdin, K. Bhattacharya

JOURNAL OF THE	
MECHANICS AND PHYSICS	
MECHANICS /	I IDO
OF SOLIDS	
13	DITORS
K. BHATTACHARYA	H. GAO
Applied Science	Division of Engineering Brown University
California inductie of technology	
EDITORIAL AD VIERS	
M. C. BOYCE-Cambridge, U.S.A.	E. VAN DER GIESSEN-Groningen.
R. J. CLIFTON-Providence, U.S.A.	The Netherlands
L. B. FREUNDProvidence, U.S.A.	W. DANG-Beijing China J. E. RICE-Carabriden, U.S.A.
I R WILLIS-Cambridge DK	N.A. FLECK-Cambridge, U.K.
(Editor 1982-2006)	J. W. HUTCHINSON-Cambridge, U.S.A.
H. HORII—Tokyo, Japan	M. ORTIZ-Paradena, U.S.A.
R. D. JAMES-Minnespolis, U.S.A.	P. SUQUET-Manselle, France
	Superstand

www.elsevier.com/locate/jmps

PII:S0022-5096(14)00121-5DOI:http://dx.doi.org/10.1016/j.jmps.2014.06.002Reference:MPS2493

To appear in: Journal of the Mechanics and Physics of Solids

Received date: 24 December 2013 Revised date: 15 May 2014 Accepted date: 11 June 2014

Cite this article as: M.Z. Hossain, C.-J. Hsueh, B. Bourdin, K. Bhattacharya, Effective toughness of heterogeneous media, *Journal of the Mechanics and Physics of Solids*, http://dx.doi.org/10.1016/j.jmps.2014.06.002

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting galley proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

ACCEPTED MANUSCRIPT

Effective toughness of heterogeneous media

M.Z. Hossain¹, C-J Hsueh¹, B. Bourdin² and K. Bhattacharya¹

 Division of Engineering and Applied Science, California Institute of Technology Pasadena, CA 91125, USA Email: zubaer@caltech.edu, bhatta@caltech.edu

2. Department of Mathematics and Center for Computation & Technology Louisiana State University Baton Rouge, LA 70803, USA Email: bourdin@lsu.edu

Abstract

We propose a versatile approach to computing the effective toughness of heterogeneous media. This approach focusses on the material property independent of the details of the boundary condition. The key idea is what we call a surfing boundary condition, where a steadily propagating crack opening displacement is applied as a boundary condition to a large domain while the crack set is allowed to evolve as it chooses. The approach is verified and used to study examples in brittle fracture. We demonstrate that effective toughness is different from effective or weighted surface area of the crack set. Further, we demonstrate that elastic heterogeneity can have a profound effect on fracture toughness: it can be a significant toughening mechanism and it can lead to toughness asymmetry wherein the toughness depends not only on direction but also on the sense of propagation. The role of length-scale is also discussed.

1 Introduction

Fracture mechanics, starting with the work of Griffith [31], is a grand success of the past century with the development of a profound theory that can describe crack propagation in complex macroscopic situations. However, this theory requires an empirical parameter – the fracture toughness. How this parameter arises, or how it changes, or even what it means in the microstructural hierarchy of materials remains incompletely understood.

Over the last few decades a number of composite structures have been developed, especially in the context of ceramics, where microstructural features have been exploited to enhance the toughness. Consequently, there is an extensive literature on the fracture toughness of composite materials, e.g. [16, 19, 23, 25, 26, 30, 35, 50]. These composites also motivated systematic mathematical formulation of the change in stress intensity with perturbations in the crack front and modulus [29, 47]. However, this work is generally limited to particular microstructures of relevance to composites.

The relation between random microstructures and observable features including morphology of crack surfaces and rate dependance has received much attention with the discovery of some universal scaling laws [10, 11, 12, 45, 46]. However, these are limited to random microstructures Download English Version:

https://daneshyari.com/en/article/7178188

Download Persian Version:

https://daneshyari.com/article/7178188

Daneshyari.com