



RESEARCH

Variational approach to viscoelastic fracture: comparison of a phase-field and a lip-field approach

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Abstract Fracture of viscoelastic materials is considered to be a complex phenomenon due to their highly rate sensitive behavior. In this context, we are interested in the quasi-static response of a viscoelastic solid subjected to damage. This paper outlines a new incremental variational based approach and its computational implementation to model damage in viscoelastic solids. The variational formalism allows us to embed the local constitutive equations into a global incremental potential, the minimization of which provides the solution to the mechanical problem. Softening damage models in their local form are known to result in spurious mesh-sensitive results, and hence, non-locality (or regularization) has to be introduced to preserve the mathematical relevance of the problem. In the present paper, we consider two different regularization techniques for the viscoelastic damage model: a particular phase-field and a lip-field approach. The model parameters are calibrated to obtain some equivalence between both these

approaches. Numerical results are then presented for the bidimensional case and both these approaches compare well. Numerical results also demonstrate the ability of the model to qualitatively represent the typical rate-dependent behaviour of the viscoelastic materials. Besides, the novelty of the present work also lies in the use of lip-field approach for the first time in a viscoelastic context.

Keywords Damage · Viscoelasticity · Lip-field · Phase-field · Variational approach

1 Introduction

Viscoelastic materials like asphalt, biological tissues, wood and polymers have numerous applications in engineering. The properties of these materials are highly rate and temperature dependent, therefore, greatly affecting their failure behavior (Lakes and Wineman 2006; D’Amico et al. 2013). Designing for the mitigation of fractures in viscoelastic materials is an important problem, for example, in the case of asphalt and pavement construction (Pirmohammad and Ayatollahi 2020).

Fracture mechanics commenced with the earlier work of Griffith (Dugdale 1921). Based on this theory, the stress at the crack tip becomes infinite. Fracture mechanics is used to characterise the loads on crack using a single parameter. A number of different parameters have been developed and used. When the non-

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The Variational Approach To Fracture The Variational Approach To Fracture

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The Variational Approach to Fracture Blaise Bourdin, Gilles A. Francfort, Jean-Jacques Marigo, 2008-04-19 Presenting original results from both theoretical and numerical viewpoints this text offers a detailed discussion of the variational approach to brittle fracture This approach views crack growth as the result of a competition between bulk and surface energy treating crack evolution from its initiation all the way to the failure of a sample The authors model crack initiation crack path and crack extension for arbitrary geometries and loads *Variational Approach to Fracture Mechanics with Plasticity* Roberto Alessi, 2013 **Applications of the Variational Approach to Fracture Mechanics** Ataollah Mesgarnejad, 2014 **A Variational Approach to Fracture and Other Inelastic Phenomena** Gianpietro Del Piero, 2013-08-30 This book exposes a number of mathematical models for fracture of growing difficulty All models are treated in a unified way based on incremental energy minimization They differ from each other by the assumptions made on the inelastic part of the total energy here called the cohesive energy Each model describes a specific aspect of material response and particular care is devoted to underline the correspondence of each model to the experiments The content of the book is a re elaboration of the lectures delivered at the First Sperlonga Summer School on Mechanics and Engineering Sciences in September 2011 In the year and a half elapsed after the course the material has been revised and enriched with new and partially unpublished results Significant additions have been introduced in the occasion of the course The variational approach to fracture and other inelastic phenomena delivered at SISSA Trieste in March 2013 The Notes reflect a research line carried on by the writer over the years addressed to a comprehensive description of the many aspects of the phenomenon of fracture and to its relations with other phenomena such as the formation of microstructure and the changes in the material's strength induced by plasticity and damage Reprinted from the Journal of Elasticity volume 112 issue 1 2013

Development of a Work-controlled Algorithm for the Variational Approach to Fracture Mechanics and Its Application to Sandstone Burst Experiments Ataollah Mesgarnejad, 2014 **Proceedings of the 2nd International Conference on Structural Damage Modelling and Assessment** Magd Abdel Wahab, 2021-12-04 This book comprises the select proceedings from the 2nd International Conference on Structural Damage Modelling and Assessment SDMA 2021 held in the city of Ghent Belgium on 4-5 August 2021 It discusses the recent advances in fields related to damage modelling damage detection and assessment non destructive testing and evaluation structure integrity and structural health monitoring The conference covers all research topics and applications relevant to structural damage modelling and assessment using theoretical numerical and experimental techniques This book is useful to scientists and engineers in academia and industry who are interested in the field of structural damage and integrity for disaster risk reduction *Advances in Computational Plasticity* Eugenio Oñate, Djordje Peric, Eduardo de Souza Neto, Michele Chiumenti, 2017-09-09 This book brings together some 20 chapters on state of the art research in the broad field of computational plasticity with applications in civil and

mechanical engineering metal forming processes geomechanics nonlinear structural analysis composites biomechanics and multi scale analysis of materials among others The chapters are written by world leaders in the different fields of computational plasticity

Discrete Volume Method : a Variational Approach for Brittle Fracture Víctor Eduardo Cardoso Nungaray, 2018 This thesis presents a proposal to simulate mechanics and dynamics of brittle fracture A variational formulation is used to describe Lagrangian mechanics by minimizing the difference between potential and kinetic energy of the system obtaining a pair of partial differential equations the solution of these equations corresponds to the displacement field and damage phase field respectively Such an equations are coupled in the sense that the damage field is used in the first equation and the displacement field is used in the second one In this work we propose a numerical method based on control volumes to solve the differential equations extending the formulation to support the separation of control volumes processing these volumes as discrete entities This treatment results in accurate calculations of stress field and the nucleation of new internal fractures that can be propagated through domain creating multiple bifurcations To integrate equations inside control volumes we introduce a family of polynomial splines that we refer as homeostatic splines since its derivatives are null at vertices with a smooth function variation between adjacent volumes Furthermore we propose a shape function with trigonometric components for dynamic analysis allowing bigger time steps that with traditional approaches Finally we perform ten numerical experiments to show the effectiveness of the method and to compare our results with those published by other authors

Modeling Anisotropic Interface Fracture Using Phase Field Cohesive Zone Approach in Composites Dhaladhuli Pranavi, Amirtham Rajagopal, 2024-12-17 Fracture is one of the major failure modes in structures and computational modeling helps in understanding the crack initiation and propagation which leads to ultimate fracture at various material length scales ranging from atomic to macro scales The book mainly focuses on developing direction dependent non local approaches for modeling different failure modes in multi phase materials Additionally it has several numerical simulations with MATLAB codes to enhance the understanding of composite failure

Design and Modeling of Mechanical Systems - II Mnaouar Chouchane, Tahar Fakhfakh, Hachmi Ben Daly, Nizar Aifaoui, Fakher Chaari, 2015-03-24 This book offers a collection of original peer reviewed contributions presented at the 6th International Congress on Design and Modeling of Mechanical Systems CMSM 2015 held in Hammamet Tunisia from the 23rd to the 25th of March 2015 It reports on both recent research findings and innovative industrial applications in the fields of mechatronics and robotics dynamics of mechanical systems fluid structure interaction and vibroacoustics modeling and analysis of materials and structures and design and manufacturing of mechanical systems Since its first edition in 2005 the CMSM Congress has been held every two years with the aim of bringing together specialists from universities and industry to present the state of the art in research and applications discuss the most recent findings and exchange and develop expertise in the field of design and modeling of mechanical systems The CMSM Congress is jointly organized by three Tunisian research laboratories the Mechanical

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