

## Numerical modelling of ductile damage mechanics coupled with an unconventional plasticity model

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**ABSTRACT.** Ductility in metals includes the material's capability to tolerate plastic deformations before partial or total degradation of its mechanical properties. Modelling this parameter is important in structure and component design because it can be used to estimate material failure under a generic multi-axial stress state. Previous work has attempted to provide accurate descriptions of the mechanical property degradation resulting from the formation, growth, and coalescence of microvoids in the medium. Experimentally, ductile damage is inherently linked with the accumulation of plastic strain; therefore, coupling damage and elastoplasticity is necessary for describing this phenomenon accurately. In this paper, we combine the approach proposed by Lemaitre with the features of an unconventional plasticity model, the extended subloading surface model, to predict material fatigue even for loading conditions below the yield stress.

**KEYWORDS.** Unconventional plasticity; Ductile damage; Subloading surface; Cyclic loading.



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### INTRODUCTION

The degradation of material properties, which results from the initiation of cavities and microcracks induced by large plastic deformations, has been widely studied. Material failure results from microscopic material imperfections, which cause the formation and coalescence of microvoids that eventually produce cracks during deformation. Modelling this mechanism is important in many industrial processes for creating optimized reliable designs for structures and components.

There are two main models for the elastoplastic framework [1, 2]: Gurson's void growth model [3] and Lemaitre's model [4, 5], often referred as continuum damage mechanics. Gurson's model is based on void growth, where the plastic yield is inversely proportional to the amount of imperfections; as the porosity increases the material loading decreases. Further studies by Needleman and Tvergaard [6], Koppic and Needleman [7], and Ohata and Toyota [8] extended the damage evolution concept by introducing material parameters to model the acceleration of the degradation of mechanical properties. Lemaitre's theory describes damage as an internal variable and models its evolution with a dissipative potential

# Numerical Modelling In Damage Mechanics

**Collectif**



## **Numerical Modelling In Damage Mechanics:**

**Numerical Modelling in Damage Mechanics** Collectif, 2001      Numerical Modelling in Damage Mechanics Khémais Saanouni, 2003 These collected writings gather recent advances in numerical and computational aspects of damage mechanics with the intention of stimulating current research and future challenges in this field      **Numerical Modelling of Failure in Advanced Composite Materials** Pedro P. Camanho, Stephen R. Hallett, 2015-08-07 Numerical Modelling of Failure in Advanced Composite Materials comprehensively examines the most recent analysis techniques for advanced composite materials Advanced composite materials are becoming increasingly important for lightweight design in aerospace wind energy and mechanical and civil engineering Essential for exploiting their potential is the ability to reliably predict their mechanical behaviour particularly the onset and propagation of failure Part One investigates numerical modeling approaches to interlaminar failure in advanced composite materials Part Two considers numerical modelling approaches to intralaminar failure Part Three presents new and emerging advanced numerical algorithms for modeling and simulation of failure Part Four closes by examining the various engineering and scientific applications of numerical modeling for analysis of failure in advanced composite materials such as prediction of impact damage failure in textile composites and fracture behavior in through thickness reinforced laminates Examines the most recent analysis models for advanced composite materials in a coherent and comprehensive manner Investigates numerical modelling approaches to interlaminar failure and intralaminar failure in advanced composite materials Reviews advanced numerical algorithms for modeling and simulation of failure Examines various engineering and scientific applications of numerical modelling for analysis of failure in advanced composite materials      Modelling of Damage Processes in Biocomposites, Fibre-Reinforced Composites and Hybrid Composites Mohammad Jawaaid, Mohamed Thariq Hameed Sultan, Naheed Saba, 2018-11-23 Modelling of Damage Processes in Biocomposites Fibre Reinforced Composites and Hybrid Composites focuses on the advanced characterization techniques used for the analysis of composite materials developed from natural fiber biomass synthetic fibers and a combination of these materials used as fillers and reinforcements to enhance materials performance and utilization in automotive aerospace construction and building components It will act as a detailed reference resource to encourage future research in natural fiber and hybrid composite materials an area much in demand due to the need for more sustainable recyclable and eco friendly composites in a broad range of applications Written by leading experts in the field and covering composite materials developed from different natural fibers and their hybridization with synthetic fibers the book s chapters provide cutting edge up to date research on the characterization analysis and modelling of composite materials Contains contributions from leading experts in the field Discusses recent progress on failure analysis SHM durability life prediction and the modelling of damage in natural fiber based composite materials Covers experimental analytical and numerical analysis Provides detailed and comprehensive information on mechanical properties testing methods and modelling techniques      *IUTAM Symposium*

*on Multiscale Modelling of Damage and Fracture Processes in Composite Materials* Tomasz Sadowski, 2006-07-06 The IUTAM Symposium on Multiscale Modelling of Damage and Fracture Processes in Composite Materials was held in Kazimierz Dolny Poland 23-27 May 2005. The Symposium was attended by 48 persons from 15 countries. During 5-day meeting 4 keynote lectures and 39 invited lectures were presented. This volume constitutes the Proceedings of the IUTAM Symposium. The main aim of the Symposium was to discuss the basic principles of damage growth and fracture processes in different types of composites: ceramic polymer and metal matrix composites, cement and bituminous composites and wood. Nowadays it is widely recognized that important macroscopic properties like the macroscopic stiffness and strength are governed by processes that occur at one to several scales below the level of observation starting from nanoscale. Understanding how these processes influence the reduction of stiffness and strength is essential for the analysis of existing and the design of improved composite materials. The study of how these various length scales can be linked together or taken into account simultaneously is particularly attractive for composite materials since they have a well-defined structure at the nano, micro and meso levels. The well-defined microstructural level can be associated with small particles or fibres while the individual laminae can be identified at the mesoscopic level. Moreover, the advances in multiscale modelling of damage and fracture processes to the description of the complete constitutive behaviour in composites which do not have a very well-defined microstructure e.g. cementitious, bituminous composites and wood was analysed.

**Damage Mechanics of Cementitious Materials and Structures** Gilles Pijaudier-Cabot, Frederic Dufour, 2013-02-07 The book prepared in honor of the retirement of Professor J. Mazars provides a wide overview of continuum damage modeling applied to cementitious materials. It starts from micro-nanoscale analyses then follows on to continuum approaches and computational issues. The final part of the book presents industry-based case studies. The contents emphasize multiscale and coupled approaches toward the serviceability and the safety of concrete structures.

**Advances in Damage Mechanics: Metals and Metal Matrix Composites** George Voyiadjis, 2012-12-02 This book provides in a single and unified volume a clear and thorough presentation of the recent advances in continuum damage mechanics for metals and metal matrix composites. Emphasis is placed on the theoretical formulation of the different constitutive models in this area but sections are added to demonstrate the applications of the theory. In addition, some sections contain new material that has not appeared before in the literature. The book is divided into three major parts. Part I deals with the scalar formulation and is limited to the analysis of isotropic damage in materials. Parts II and III deal with the tensor formulation and is applied to general states of deformation and damage. The material appearing in this text is limited to plastic deformation and damage in ductile materials e.g. metals and metal matrix composites but excludes many of the recent advances made in creep, brittle fracture and temperature effects since the authors feel that these topics require a separate volume for this presentation. Furthermore, the applications presented in this book are the simplest possible ones and are mainly based on the uniaxial tension test.

**Recent Trends**

**in Fracture and Damage Mechanics** Geralf Hütter, Lutz Zymbel, 2015-09-01 This book covers a wide range of topics in fracture and damage mechanics. It presents historical perspectives as well as recent innovative developments presented by peer reviewed contributions from internationally acknowledged authors. The volume deals with the modeling of fracture and damage in smart materials, current industrial applications of fracture mechanics and it explores advances in fracture testing methods. In addition, readers will discover trends in the field of local approach to fracture and approaches using analytical mechanics. Scholars in the fields of materials science, engineering and computational science will value this volume which is dedicated to Meinhard Kuna on the occasion of his 65th birthday in 2015. This book incorporates the proceedings of an international symposium that was organized to honor Meinhard Kuna's contributions to the field of theoretical and applied fracture and damage mechanics.

Numerical Modelling of Ductile Fracture Odd Perry Søvik, 1996

Damage and Healing Mechanics of Materials George Z. Voyiadjis, Peter I. Kattan, 2025-06-27

Damage and Healing Mechanics of Materials: Metals and Metal Matrix Composites covers the fundamentals of damage mechanics with various damage models presented coupled with elastic and elastoplastic behavior. Experimental investigations and the related data for damage in composite materials are included as are computational modeling and simulation methods for investigating damage and healing in various materials and structures. Healing mechanics using both scalars and more general theory based on tensor notations are discussed as are applications of damage mechanics. Undamageable materials, the generalized method of cells, phase field modeling, cyclic plasticity concepts and more are all also covered. Introduces computational methods and numerical techniques such as finite element analysis and molecular dynamics to model and simulate damage and healing in various materials and structures. Discusses the ways cracks and voids are subjected to healing mechanisms and new composites that are designed to be more resilient and resistant to damage. Covers uniaxial tension in metal matrix composites, damage and plasticity in metals, experimental damage investigation techniques, anisotropic healing and more.

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