

MECHANICAL ENGINEERING SERIES

Pierre Ladevèze

# Nonlinear Computational Structural Mechanics

New Approaches and  
Non-Incremental Methods  
of Calculation

Translated by James G. Simmonds



Springer

# Nonlinear Computational Structural Mechanics New Approaches And Non Incremental Methods Of Calculation

**David G. Hull**



## **Nonlinear Computational Structural Mechanics New Approaches And Non Incremental Methods Of Calculation:**

**Nonlinear Computational Structural Mechanics** Pierre Ladeveze, 2012-12-06 Mechanical Engineering an engineering discipline borne of the needs of the industrial revolution is once again asked to do its substantial share in the call for industrial renewal The general call is urgent as we face profound issues of productivity and competitiveness that require engineering solutions among others The Mechanical Engineering Series features graduate texts and research monographs intended to address the need for information in contemporary areas of mechanical engineering The series is conceived as a comprehensive one that covers a broad range of concentrations important to mechanical engineering graduate education and research We are fortunate to have a distinguished roster of consulting editors on the advisory board each an expert in one of the areas of concentration The names of the consulting editors are listed on the next page of this volume The areas of concentration are applied mechanics biomechanics computational mechanics dynamic systems and control energetics mechanics of materials processing thermal science and tribology Frederick A Leckie the series editor for applied mechanics and I are pleased to present this volume in the Series Nonlinear Computational Structural Mechanics New Approaches and Non Incremental Methods of Calculation by Pierre Ladeveze The selection of this volume underscores again the interest of the Mechanical Engineering series to provide our readers with topical monographs as well as graduate texts in a wide variety of fields Mastering Calculations in Linear and Nonlinear Mechanics Pierre Ladevèze, Jean Pierre Pelle, 2004-12-16

This book deals with the management of calculations in linear and nonlinear mechanics Particular attention is given to error estimators and indicators for structural analysis The accent is on the concept of error in constitutive relation An important part of the work is also devoted to the utilization of the error estimators involved in a calculation beginning with the parameters related to the mesh Many of the topics are taken from the most recent research by the authors local error estimators extension of the concept of error in constitutive relation to nonlinear evolution problems and dynamic problems adaptive improvement of calculations in nonlinear mechanics This work is intended for all those interested in mechanics students researchers and engineers concerned with the construction of models as well as their simulation for industrial purposes

**Numerical Methods for Strong Nonlinearities in Mechanics** Jacques Besson, Frederic Lebon, Eric Lorentz, 2025-01-09 Numerical Methods for Strong Nonlinearities in Mechanics deals with recent advances in the numerical treatment of contact friction and damage phenomena Although physically distinct these phenomena both lead to a strong nonlinearity in the mechanical problem therefore limiting the regularity of the problem which is now non differentiable This has two direct consequences on the one hand the mathematical characteristics of the problem deviate from well established forms requiring innovative discretization schemes on the other hand the low regularity makes it particularly difficult to solve the corresponding large scale algebraic systems robustly and efficiently In addition neither the uniqueness nor the existence of solutions remain assured resulting in bifurcation points limit loads and structural instabilities which are always tricky to

overcome numerically      **Fundamentals of Surface Mechanics** Frederick F. Ling, W. Michael Lai, Don A.

Lucca, 2012-08-10 Mechanical engineering an engineering discipline borne of the needs of the industrial revolution is once again asked to do its substantial share in the call for industrial renewal The general call is urgent as we face profound issues of productivity and competitiveness that require engineering solutions among others The Mechanical Engineering Series features graduate texts and research monographs intended to address the need for information in contemporary areas of mechanical engineering The series is conceived as a comprehensive one that covers a broad range of concentrations important to mechanical engineering graduate education and research We are fortunate to have a distinguished roster of consulting editors on the advisory board each an expert in one of the areas of concentration The names of the consulting editors are listed on the next page of this volume The areas of concentration are applied mechanics biomechanics computational mechanics dynamic systems and control energetics mechanics of materials processing thermal science and tribology      **Optimal Control Theory for Applications** David G. Hull, 2013-03-09 Mechanical engineering an engineering

discipline born of the needs of the industrial revolution is once again asked to do its substantial share in the call for industrial renewal The general call is urgent as we face profound issues of productivity and competitiveness that require engineering solutions among others The Mechanical Engineering Series is a series featuring graduate texts and research monographs intended to address the need for information in contemporary areas of mechanical engineering The series is conceived as a comprehensive one that covers a broad range of concentrations important to mechanical engineering graduate education and research We are fortunate to have a distinguished roster of consulting editors each an expert in one of the areas of concentration The names of the consulting editors are listed on page ii of this volume The areas of concentration are applied mathematics biomechanics computational mechanics dynamic systems and control energetics mechanics of materials processing thermal science and tribology Austin Texas Frederick F Ling Preface Optimization is an area of mathematics that is concerned with finding the best points curves surfaces and so on Best is determined by minimizing some measure of performance subject to equality and inequality constraints Points are constrained by algebraic equations curves are constrained by ordinary differential equations and algebraic equations surfaces are constrained by partial differential equations ordinary differential equations and algebraic equations      *Simplified Theory of Plastic Zones*

Hartwig Hübel, 2016-06-29 The present book provides a new method to estimate elastic plastic strains via a series of linear elastic analyses For a life prediction of structures subjected to variable loads frequently encountered in mechanical and civil engineering the cyclically accumulated deformation and the elastic plastic strain ranges are required The Simplified Theory of Plastic Zones STPZ is a direct method which provides the estimates of these and all other mechanical quantities in the state of elastic and plastic shakedown The STPZ is described in detail with emphasis on the fact that not only scientists but engineers working in applied fields and advanced students are able to get an idea of the possibilities and limitations of the

STPZ Numerous illustrations and examples are provided to support the reader's understanding *Multi-mechanism Modeling of Inelastic Material Behavior* Georges Cailletaud, Lakhdar Taleb, Kacem Sai, 2017-12-27 This book focuses on a particular class of models namely Multi Mechanism models and their applications to extensive experimental data base related to different kind of materials These models i are able to describe the main mechanical effects in plasticity creep creep plasticity interaction ratcheting extra hardening under non proportional loading ii provide local information such as local stress strain fields damage A particular attention is paid to the identification process of material parameters Moreover finite element implementation of the Multi Mechanism models is detailed

**High Performance and Optimum Design of Structures and Materials II** S. Hernández, C.A. Brebbia, W.P. De Wilde, 2016-11-28 Containing papers from the 2nd High Performance Design of Structures and Materials and the Optimum Design of Structures conference following the success of a number of meetings since 1989 this book will be of interest to those in any engineering field The use of novel materials and new structural concepts nowadays is not restricted to highly technical areas like aerospace aeronautical applications or the automotive industry but affects all engineering fields including those such as civil engineering and architecture Most high performance structures require the development of a generation of new higher performance sustainable materials which can more easily resist a range of external stimuli or react in a non conventional manner Emphasis is placed on intelligent structures and materials as well as the application of computational methods for their modelling control and management Optimisation problems of interest involve those related to size shape and topology of structures and materials Optimisation techniques have much to offer to those involved in the design of new industrial products The development of new algorithms and the appearance of powerful commercial computer codes with easy to use graphical interfaces have created a fertile field for the incorporation of optimisation into the design process in all engineering disciplines The book addresses the topic of design optimisation with welcomed contributions on numerical methods different optimisation techniques and new software Several of the topics covered are Composite materials and structures Material characterisation Experiments and numerical analysis Transformable structures Environmentally friendly and sustainable structures Evolutionary methods in optimisation Aerospace structures Biomechanics application and Pneumatic structures

**Fracture Mechanics** Huy Duong Bui, 2007-01-03 This book is an outgrowth of my involvement in two groups of research in solid mechanics created in 1960 for the French nuclear energy program At this time it was decided that France as a no oil reservoir country must be powered by nuclear energy which represents today 80% of the total tional energy supply Long before the construction of the first nuclear plant at Fessenheim in 1973 Electricit de France EdF created its first solid mechanics laboratory appointed researchers and sent them to the universities or abroad in order to learn about theories and new methods of assessment of the safety of structures Working at EdF I was training in Professor Jean Mandel's laboratory at Ecole Polytechnique LMS Paris My friend Ren Labbens working at Framatome the builder of nuclear plants was training at the Lehigh University under the guidance of

professors G R Irwin and G C Sih We had to work hard both academically at the universities laboratories and performing engineering tasks for our employer This dual position was a great chance for many of us since we discovered that real industrial problems are the source of new subjects and research problems to be solved by theoreticians in the universities and conversely we immediately knew if our theoretical work was good or not for applications as revealed in our daily works conducted for our industrial employer

**Verifying Calculations - Forty Years On** Ludovic Chamoin, Pedro Díez, 2015-08-05 This work provides an overview of a posteriori error assessment techniques for Finite Element FE based numerical models These tools aim at estimating and controlling the discretization error in scientific computational models being the basis for the numerical verification of the FE solutions The text discusses the capabilities and limitations of classical methods to build error estimates which can be used to control the quality of numerical simulations and drive adaptive algorithms with a focus on Computational Mechanics engineering applications Fundamentals principles of residual methods smoothing recovery methods and constitutive relation error duality based methods are thus addressed along the manuscript Attention is paid to recent advances and forthcoming research challenges on related topics The book constitutes a useful guide for students researchers or engineers wishing to acquire insights into state of the art techniques for numerical verification

Nonlinear Analysis of Thin-Walled Structures James F. Doyle, 2013-03-09 Mechanical engineering an engineering discipline born of the needs of the Industrial Revolution is once again asked to do its substantial share in the call for industrial renewal The general call is urgent as we face the profound issues of productivity and competitiveness that require engineering solutions among others The Mechanical Engineering Series is a new series featuring graduate texts and research monographs intended to address the need for information in contemporary areas of mechanical engineering The series is conceived as a comprehensive one that will cover a broad range of concentrations important to mechanical engineering graduate education and research We are fortunate to have a distinguished roster of consulting editors each an expert in one of the areas of concentration The names of the consulting editors are listed on page vi The areas of concentration are applied mechanics biomechanics computational mechanics dynamic systems and control energetics mechanics of materials processing thermal science and tribology We are pleased to present Nonlinear Analysis of Thin Walled Structures by James F Doyle Austin Texas Frederick F Ling Preface This book is concerned with the challenging subject of the nonlinear static dynamic and stability analyses of thin walled structures It carries on from where Static and Dynamic Analysis of Structures published by Kluwer 1991 left off that book concentrated on frames and linear analysis while the present book is focused on plated structures nonlinear analysis and a greater emphasis on stability analysis

Current Trends and Open Problems in Computational Mechanics Fadi Aldakheel, Blaž Hudobivnik, Meisam Soleimani, Henning Wessels, Christian Weißenfels, Michele Marino, 2022-03-12 This Festschrift is dedicated to Professor Dr Ing habil Peter Wriggers on the occasion of his 70th birthday Thanks to his high dedication to research over the years Peter Wriggers has

built an international network with renowned experts in the field of computational mechanics This is proven by the large number of contributions from friends and collaborators as well as former PhD students from all over the world The diversity of Peter Wriggers network is mirrored by the range of topics that are covered by this book To name only a few these include contact mechanics finite virtual element technologies micromechanics multiscale approaches fracture mechanics isogeometric analysis stochastic methods meshfree and particle methods Applications of numerical simulation to specific problems e g Biomechanics and Additive Manufacturing is also covered The volume intends to present an overview of the state of the art and current trends in computational mechanics for academia and industry Higher Gradient Materials and Related Generalized Continua Holm Altenbach, Wolfgang H. Müller, Bilen Emek Abali, 2019-11-04 This book discusses recent findings and advanced theories presented at two workshops at TU Berlin in 2017 and 2018 It underlines several advantages of generalized continuum models compared to the classical Cauchy continuum which although widely used in engineering practice has a number of limitations such as The structural size is very small The microstructure is complex The effects are localized As such the development of generalized continuum models is helpful and results in a better description of the behavior of structures or materials At the same time there are more and more experimental studies supporting the new models because the number of material parameters is higher Computational Modelling of Concrete Structures Nenad Bicanic, Herbert Mang, Gunther Meschke, René de Borst, 2014-03-04 The EURO C conference series Split 1984 Zell am See 1990 Innsbruck 1994 Badgastein 1998 St Johann im Pongau 2003 Mayrhofen 2006 Schladming 2010 St Anton am Alberg 2014 brings together researchers and practising engineers concerned with theoretical algorithmic and validation aspects associated with computational simulations of concrete and **Ceramic Matrix Composites** Narottam P. Bansal, Jacques Lamon, 2014-10-27 This book is a comprehensive source of information on various aspects of ceramic matrix composites CMC It covers ceramic and carbon fibers the fiber matrix interface processing properties and industrial applications of various CMC systems architecture mechanical behavior at room and elevated temperatures environmental effects and protective coatings foreign object damage modeling life prediction integration and joining Each chapter in the book is written by specialists and internationally renowned researchers in the field This book will provide state of the art information on different aspects of CMCs The book will be directed to researchers working in industry academia and national laboratories with interest and professional competence on CMCs The book will also be useful to senior year and graduate students pursuing degrees in ceramic science and engineering materials science and engineering aeronautical mechanical and civil or aerospace engineering Presents recent advances new approaches and discusses new issues in the field such as foreign object damage life predictions multiscale modeling based on probabilistic approaches etc Caters to the increasing interest in the application of ceramic matrix composites CMC materials in areas as diverse as aerospace transport energy nuclear and environment CMCs are considered an enabling technology for advanced aeropropulsion space propulsion space power

aerospace vehicles space structures as well as nuclear and chemical industries Offers detailed descriptions of ceramic and carbon fibers fiber matrix interface processing properties and industrial applications of various CMC systems architecture mechanical behavior at room and elevated temperatures environmental effects and protective coatings foreign object damage modeling life prediction integration joining      *Snapshot-Based Methods and Algorithms* Peter Benner, et al., 2020-12-16 An increasing complexity of models used to predict real world systems leads to the need for algorithms to replace complex models with far simpler ones while preserving the accuracy of the predictions This two volume handbook covers methods as well as applications This second volume focuses on applications in engineering biomedical engineering computational physics and computer science      **Multiscale Methods** Jacob Fish, 2010 Small scale features and processes occurring at nanometer and femtosecond scales have a profound impact on what happens at a larger scale and over an extensive period of time The primary objective of this volume is to reflect the state of the art in multiscale mathematics modeling and simulations and to address the following barriers What is the information that needs to be transferred from one model or scale to another and what physical principles must be satisfied during the transfer of information What are the optimal ways to achieve such transfer of information How can variability of physical parameters at multiple scales be quantified and how can it be accounted for to ensure design robustness The multiscale approaches in space and time presented in this volume are grouped into two main categories information passing and concurrent In the concurrent approaches various scales are simultaneously resolved whereas in the information passing methods the fine scale is modeled and its gross response is infused into the continuum scale The issue of reliability of multiscale modeling and simulation tools which focus on a hierarchy of multiscale models and an a posteriori model of error estimation including uncertainty quantification is discussed in several chapters Component software that can be effectively combined to address a wide range of multiscale simulations is also described Applications range from advanced materials to nanoelectromechanical systems NEMS biological systems and nanoporous catalysts where physical phenomena operates across 12 orders of magnitude in time scales and 10 orders of magnitude in spatial scales This volume is a valuable reference book for scientists engineers and graduate students practicing in traditional engineering and science disciplines as well as in emerging fields of nanotechnology biotechnology microelectronics and energy      *Computational Modelling of Concrete Structures* Günther Meschke, Bernhard Pichler, Jan G. Rots, 2018-01-31 The EURO C conference series Split 1984 Zell am See 1990 Innsbruck 1994 Badgastein 1998 St Johann im Pongau 2003 Mayrhofen 2006 Schladming 2010 St Anton am Arlberg 2014 and Bad Hofgastein 2018 brings together researchers and practising engineers concerned with theoretical algorithmic and validation aspects associated with computational simulations of concrete and concrete structures Computational Modelling of Concrete Structures reviews and discusses research advancements and the applicability and robustness of methods and models for reliable analysis of complex concrete reinforced concrete and pre stressed concrete structures in engineering practice The



contributions cover both computational mechanics and computational modelling aspects of the analysis and design of concrete and concrete structures Multi scale cement and concrete research experiments and modelling Aging concrete from very early ages to decades long durability Advances in material modelling of plain concrete Analysis of reinforced concrete structures Steel concrete interaction fibre reinforced concrete and masonry Dynamic behaviour from seismic retrofit to impact simulation Computational Modelling of Concrete Structures is of special interest to academics and researchers in computational concrete mechanics as well as industry experts in complex nonlinear simulations of concrete structures

**Structural Synthesis in Precision Elasticity** Yakov M Tseytlin, 2007-03-20 Structural Synthesis in Precision Elasticity reflects the summary of theoretical and experimental studies whose conclusions are effective for optimized structural synthesis in precision elasticity as well as demonstrate a large experience and options in the synthesis production application of precision elastic guides mechanisms correctors transducers instruments and machines The main focus of this book is in the possible simplification of the corresponding analytical apparatus by using kinematical equivalents matrix methods appropriate contours and function expansion with enough accurate minimal polynomials This approach allows for substitution of some known unwieldy formulae and methods that are not convenient for digestible and tractable synthesis The book consists of two main parts The elastic systems functional analysis and structural synthesis methods including effective approximations and references to the history of their development The application and development of precision functional elastic systems at reference and operating conditions including the observation of archives with effective synthesized structures and elements of nanotechnology Each part provides theoretical basics and a large variety of examples and recommendations This book gives theoretical and practical tools to researchers precision machines instruments and miniature systems designers engineers metrologists and engineering students Despite that this book is dedicated to the general problems of the structural synthesis in precision elasticity most of the practical examples and applications are concerned with the measuring systems as the precision is their main goal The author intends to show close connection between the elastic precision structures developed during the 20th century and even before and the new elastic systems for atomic force microscopy and other recently created advanced structures in precision elasticity

*Computational Methods for Plasticity* Eduardo A. de Souza Neto, Djordje Peric, David R. J. Owen, 2011-09-21 The subject of computational plasticity encapsulates the numerical methods used for the finite element simulation of the behaviour of a wide range of engineering materials considered to be plastic i.e. those that undergo a permanent change of shape in response to an applied force Computational Methods for Plasticity Theory and Applications describes the theory of the associated numerical methods for the simulation of a wide range of plastic engineering materials from the simplest infinitesimal plasticity theory to more complex damage mechanics and finite strain crystal plasticity models It is split into three parts basic concepts small strains and large strains Beginning with elementary theory and progressing to advanced complex theory and computer

implementation it is suitable for use at both introductory and advanced levels The book Offers a self contained text that allows the reader to learn computational plasticity theory and its implementation from one volume Includes many numerical examples that illustrate the application of the methodologies described Provides introductory material on related disciplines and procedures such as tensor analysis continuum mechanics and finite elements for non linear solid mechanics Is accompanied by purpose developed finite element software that illustrates many of the techniques discussed in the text downloadable from the book s companion website This comprehensive text will appeal to postgraduate and graduate students of civil mechanical aerospace and materials engineering as well as applied mathematics and courses with computational mechanics components It will also be of interest to research engineers scientists and software developers working in the field of computational solid mechanics

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