

Shape and Thickness Optimization Performance of a Beam Structure by Sequential Quadratic Programming Method

A. Jarraya · F. Dammak · S. Abid · M. Haddar

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Abstract Successful performance of beam structures is critical to failure prevention, and beam performance can be optimized by careful consideration of beam shape and thickness. Shape and thickness optimization of beam structures having linear behaviour is treated. The first problem considered is the thickness distribution of the beam where the optimization variable is the thickness of the control points. The second problem is the shape optimization where the optimization variables are the ordinates of the control points. The optimization criterion (function objective to be minimized) is defined starting with the Von Mises criterion expressed in plane constraints. The resolution of the mechanical problem is made by the finite element method, and the optimization algorithm is the sequential quadratic programming (SQP) method.

Keywords Finite elements · Beams element · Parameterization · Optimization · Sequential quadratic programming method

Introduction

The optimization of structures with linear mechanical behaviour (small displacement) was widely treated over the last two decades. Powerful methods were developed to treat a large variety of problems. Gill [1] and various

commercial software (such as *ANSYS*, *NASTRAN*, *IDEAS*, and *SAMCEF*) contain structural optimization modules. Dimensioning problems (in particular the optimization of thickness or shape) have been treated by several investigators, for example the works of Boisserie, Glowinski [2], Fleury [3], Abid [4] and Vanderplaats and Moses [5]. The variables treated were the nodes and sections of bars. Zienkiewicz and Campbell [6], K Choi and Duan [7], and Vinot et al. [8] generalized the concept by systematically using the finite element method. The approach described in this work is based on a discrete finite-element analysis considering the effect of membrane, bending, and transverse shear in isotropic materials. Parameterization is achieved by B-Spline of orders three and four and by the points of Bezier. A formulation of the optimization problem is made using an objective function, which considers both the mechanical constraints and the volume of the structure. The constraints are represented by the Von Mises criteria for isotropic material. For all examples treated, the selected objective function allowed the simultaneous reduction in the total state of the structural constraints and an estimate of the gradients of the objective function. The numerical technique used is based on the finite differences method. The steps followed in this article are: (1) formulation of the beam element, (2) choice of the objective function, (3) implementation of parameterization techniques, (4) resolution of the optimization problem, and finally some examples and applications.

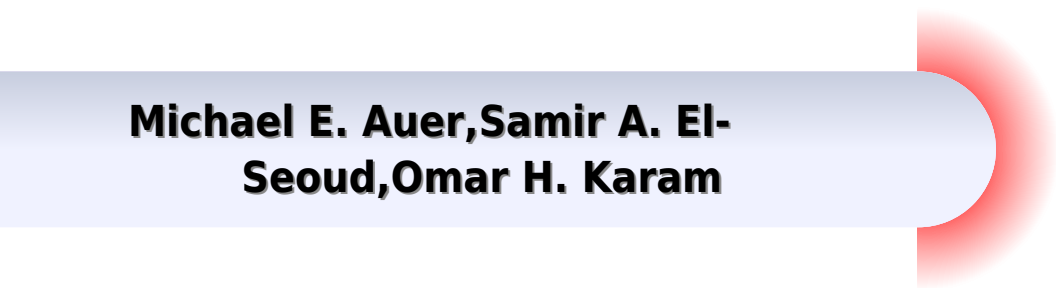
Formulation of the Beam Element

The relations presented characterize the theory of the beams in bending by taking into account the influence of

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Shape And Thickness Optimization Performance Of A Beam

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Advanced Engineering Optimization Through Intelligent Techniques Ravipudi Venkata Rao, Jan Taler, 2023-04-07
This book comprises peer reviewed papers presented at the International Conference on Advanced Engineering Optimization Through Intelligent Techniques AEOTIT 2022. The book combines contributions from academics and industry professionals and covers advanced optimization techniques across all major engineering disciplines like mechanical, manufacturing, civil, automobile, electrical, chemical, computer, and electronics engineering. The book discusses different optimization techniques and algorithms such as genetic algorithm, non-dominated sorting genetic algorithm II and III, differential search, particle swarm optimization, fruit fly algorithm, cuckoo search, teaching learning based optimization, algorithm grey wolf optimization, Jaya algorithm, Rao algorithms, and many other latest meta-heuristic techniques and their applications. Various multi-attribute decision making methods such as AHP, TOPSIS, ELECTRE, PROMETHEE, DEMATEL, R method, fuzzy logic, and their applications are also discussed. This book serves as a valuable reference for students, researchers, and practitioners and helps them in solving a wide range of optimization problems. *Shock & Vibration, Aircraft/Aerospace, and Energy Harvesting, Volume 9* Alfred Wicks, 2025-08-07. Shock Vibration Aircraft Aerospace Energy Harvesting Volume 9. Proceedings of the 33rd IMAC A Conference and Exposition on Structural Dynamics 2015, the ninth volume of ten from the Conference brings together contributions to this important area of research and engineering. The collection presents early findings and case studies on fundamental and applied aspects of Shock Vibration Aircraft Aerospace Energy Harvesting, including papers on Energy Harvesting, Adaptive Support, Shock Calibration, Operating Data Applications. Recent Advances in Multidisciplinary Analysis and Optimization, 1989. Advances in Machinery, Materials Science and Engineering Application IX Min Chen, Marco Giorgetti, Bo Jin, Ramesh K. Agarwal, 2023-11-15. New engineering materials techniques and applications are constantly being researched and developed, and keeping up to speed with the latest advances is crucial for engineers if they are to successfully address the challenges they face in their work. This book presents the selected proceedings of MMSE2023, the 9th International Conference on Advances in Machinery, Materials Science and Engineering Applications, jointly organized by the SAE Suprema France and China University of Geosciences Wuhan and held on 22 and 23 July 2023 in Wuhan, China. For the past 12 years, this annual conference has collated recent advances and experiences, identified emerging trends, and provided a platform for participants from academia and industry to exchange information and views, helping to address the world's machinery and engineering challenges. The book contains 4 sections: mechanical engineering, material science and manufacturing technology, electrical engineering, automation and control, modeling, simulation, and optimization techniques in engineering and advanced engineering technologies and applications. A total of 241 submissions were received for MMSE2023, of which 151 papers were selected for the conference and for publication by means of a rigorous international peer review process. These papers present exciting ideas and methods that will open novel research

directions for different communities Offering a current overview of the latest research and applications in machinery and materials science engineering the book will be of interest to all those working in the field

Proceedings of China SAE Congress 2023: Selected Papers China Society of Automotive Engineers,2024-02-20 This book gathers outstanding papers presented at the China SAE Congress 2023 featuring contributions mainly from China the biggest carmaker as well as most dynamic car market in the world The book covers a wide range of automotive related topics and the latest technical advances in the industry Many of the approaches in the book help technicians to solve practical problems that affect their daily work In addition the book offers valuable technical support to engineers researchers and postgraduate students in the field of automotive engineering

Proceedings of China SAE Congress 2019: Selected Papers China Society of Automotive Engineers,2020-11-04 These proceedings gather outstanding papers presented at the China SAE Congress 2019 Featuring contributions mainly from China the biggest carmaker as well as most dynamic car market in the world the book covers a wide range of automotive topics and the latest technical advances in the industry Many of the approaches included can help technicians to solve practical problems that affect their daily work In addition the book offers valuable technical support to engineers researchers and postgraduate students in the field of automotive engineering

Comprehensive Semiconductor Science and Technology ,2011-01-28 Semiconductors are at the heart of modern living Almost everything we do be it work travel communication or entertainment all depend on some feature of semiconductor technology Comprehensive Semiconductor Science and Technology Six Volume Set captures the breadth of this important field and presents it in a single source to the large audience who study make and exploit semiconductors Previous attempts at this achievement have been abbreviated and have omitted important topics Written and Edited by a truly international team of experts this work delivers an objective yet cohesive global review of the semiconductor world The work is divided into three sections The first section is concerned with the fundamental physics of semiconductors showing how the electronic features and the lattice dynamics change drastically when systems vary from bulk to a low dimensional structure and further to a nanometer size Throughout this section there is an emphasis on the full understanding of the underlying physics The second section deals largely with the transformation of the conceptual framework of solid state physics into devices and systems which require the growth of extremely high purity nearly defect free bulk and epitaxial materials The last section is devoted to exploitation of the knowledge described in the previous sections to highlight the spectrum of devices we see all around us Provides a comprehensive global picture of the semiconductor world Each of the work s three sections presents a complete description of one aspect of the whole Written and Edited by a truly international team of experts

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Artificial Intelligence and Online Engineering Michael E. Auer, Samir A. El-Seoud, Omar H. Karam, 2022-10-14 Nowadays online technologies are the core of most fields of engineering and the whole society and are inseparable connected for example with Internet of Things Industrial Internet of Things Industry 4 0 Online Biomedical Engineering Data Science Machine Learning and Artificial Intelligence Cross Mixed Reality and Remote Working Environments to name only a few Since the first REV conference in 2004 we tried to focus on the upcoming use of the Internet for engineering tasks and the opportunities as well as challenges around it Consequently the motto of this year s REV2022 was Artificial Intelligence and Online Engineering In a globally connected world the interest in online collaboration teleworking remote services and other digital working environments is rapidly increasing In response to that the general objective of this conference is to contribute and discuss fundamentals applications and experiences in the field of Online and Remote Engineering Virtual Instrumentation and other related new technologies like Cross Reality Data Science Big Data Internet of Things Industrial Internet of Things Industry 4 0 Cyber Security and M2M Smart Objects Another objective of the conference is to discuss guidelines and new concepts for engineering education in higher and vocational education institutions including emerging technologies in learning MOOCs MOOLs and Open Resources REV2022 was the 19th in a series of annual events concerning the area of Online Engineering It has been organized in cooperation with The British University in Egypt BUE Cairo as a hybrid event from February 28 until March 02 2022

Hot Stamping Advanced Manufacturing Technology of Lightweight Car Body Ping Hu, Liang Ying, Bin He, 2016-10-14 This book summarizes the advanced manufacturing technology of original innovations in hot stamping of lightweight car body A detailed description of the technical system and basic knowledge of sheet metal forming is given which helps readers quickly understand the relevant knowledge in the field Emphasis has been placed on the independently developed hot stamping process and equipment which help describe the theoretical and experimental research on key problems involving stress field thermal field and phase transformation field in hot stamping process Also a description of the formability at elevated temperature and the numerical simulation algorithms for high strength steel hot stamping is given in combination with the experiments Finally the book presents some application cases of hot stamping technology such as the lightweight car body design using hot stamping components and gradient hardness components and the cooling design of the stamping tool This book is intended for researchers engineers and graduate students in vehicle engineering mechanical engineering especially in the field of advanced manufacturing technology The book also provides a useful reference for other new technology related temperature and phase transformation such as aluminum magnesium alloy hot stamping

Proceedings of the ASME Noise Control and

Acoustics Division American Society of Mechanical Engineers. Noise Control and Acoustics Division, 1997 Among the subjects covered in 50 some papers from symposia at the November 1997 meeting radiation and scattering of sound measurement and signal processing of sound fields vibroacoustic methods in processing and characterization of advanced materials and structures powertrain noise acoustics an

Advanced Techniques in Porous Structure Design for Additive Manufacturing Musaddiq Al Ali, 2025-07-03 Concise practical guide presenting skills to integrate porous structure design with additive manufacturing requirements Part of Wiley's Additive Manufacturing Skills in Practice series and written with the industry practitioner in mind Advanced Techniques in Porous Structure Design for Additive Manufacturing addresses the growing integration of porous structures and additive manufacturing essential for applications in the biomedical aerospace and automotive fields in which porous structures are crucial due to their ability to deliver top notch performance alongside lightweight characteristics This book covers all areas of the subject and concludes with a series of specialized chapters devoted to simulation software case studies and future trends and emerging technologies Each chapter features a design problem that presents an open ended scenario to prompt readers to think through the real world applications of the concepts and theories discussed and connect them to their own job roles Topics discussed in Advanced Techniques in Porous Structure Design for Additive Manufacturing include Fundamentals of additive manufacturing covering processes materials and design considerations Mathematical modeling covering optimization techniques and the finite element method Multiscale topology optimization shape optimization methods and post processing techniques Software utilization in porous structure design with information on how to program simulations Porous structures in soft robotics porous heat sinks porous plates and porous mechanical support structures With a blend of theoretical understanding and hands on expertise in an emerging domain Advanced Techniques in Porous Structure Design for Additive Manufacturing is an essential reference for industry professionals researchers and postgraduate students in universities particularly those specializing in mechanical design and additive manufacturing

Topics in Modal Analysis & Testing, Volume 10 Michael Mains, 2016-05-26 Topics in Modal Analysis Testing Volume 10 Proceedings of the 34th IMAC A Conference and Exposition on Dynamics of Multiphysical Systems From Active Materials to Vibroacoustics 2016 the tenth volume of ten from the Conference brings together contributions to this important area of research and engineering The collection presents early findings and case studies on fundamental and applied aspects of Structural Dynamics including papers on Modal Analysis Measurements Parameter Estimation Basics of Modal Analysis Additive Manufacturing Modal Testing of Printed Parts Modal Analysis Model Updating Modal Testing Methods

Engineering Design Reliability Handbook Efstratios Nikolaidis, Dan M. Ghiocel, Suren Singhal, 2004-12-22 Researchers in the engineering industry and academia are making important advances on reliability based design and modeling of uncertainty when data is limited Non deterministic approaches have enabled industries to save billions by reducing design and warranty costs and by improving quality Considering the lack of comprehensive and definitive

presentations on the subject Engineering Design Reliability Handbook is a valuable addition to the reliability literature It presents the perspectives of experts from the industry national labs and academia on non deterministic approaches including probabilistic interval and fuzzy sets based methods generalized information theory Dempster Shaffer evidence theory and robust reliability It also presents recent advances in all important fields of reliability design including modeling of uncertainty reliability assessment of both static and dynamic components and systems design decision making in the face of uncertainty and reliability validation The editors and the authors also discuss documented success stories and quantify the benefits of these approaches With contributions from a team of respected international authors and the guidance of esteemed editors this handbook is a distinctive addition to the acclaimed line of handbooks from CRC Press

Intelligent Systems for Engineers and Scientists, Third Edition Adrian A. Hopgood, 2011-12-12 The third edition of this bestseller examines the principles of artificial intelligence and their application to engineering and science as well as techniques for developing intelligent systems to solve practical problems Covering the full spectrum of intelligent systems techniques it incorporates knowledge based systems computational intelligence and their hybrids Using clear and concise language Intelligent Systems for Engineers and Scientists Third Edition features updates and improvements throughout all chapters It includes expanded and separated chapters on genetic algorithms and single candidate optimization techniques while the chapter on neural networks now covers spiking networks and a range of recurrent networks The book also provides extended coverage of fuzzy logic including type 2 and fuzzy control systems Example programs using rules and uncertainty are presented in an industry standard format so that you can run them yourself The first part of the book describes key techniques of artificial intelligence including rule based systems Bayesian updating certainty theory fuzzy logic types 1 and 2 frames objects agents symbolic learning case based reasoning genetic algorithms optimization algorithms neural networks hybrids and the Lisp and Prolog languages The second part describes a wide range of practical applications in interpretation and diagnosis design and selection planning and control The author provides sufficient detail to help you develop your own intelligent systems for real applications Whether you are building intelligent systems or you simply want to know more about them this book provides you with detailed and up to date guidance Check out the significantly expanded set of free web based resources that support the book at <http://www.adrianhopgood.com/aitoolkit>

MEGADESIGN and MegaOpt - German Initiatives for Aerodynamic Simulation and Optimization in Aircraft Design Norbert Kroll, Dieter Schwamborn, Klaus Becker, Herbert Rieger, Frank Thiele, 2009-11-18 This volume contains results of the German CFD initiative MEGADESIGN which combines CFD development activities from DLR universities and aircraft industry Based on the DLR flow solvers FLOWer and TAU the main objectives of the four years project is to ensure the prediction accuracy with a guaranteed error bandwidth for certain aircraft configurations at design conditions to reduce the simulation turn around time for large scale applications significantly to improve the reliability of the flow solvers for full aircraft configurations in the complete flight

regime to extend the flow solvers to allow for multidisciplinary simulations and to establish numerical shape optimization as a vital tool within the aircraft design process This volume highlights recent improvements and enhancements of the flow solvers as well as new developments with respect to aerodynamic and multidisciplinary shape optimization Improved numerical simulation capabilities are demonstrated by several industrial applications *MEMS: A Practical Guide of Design, Analysis, and Applications* Jan Korvink, Oliver Paul, 2010-05-28 MEMS are rapidly moving from the research laboratory to the marketplace Many market studies indicate not only a tremendous market potential of MEMS devices year by year we see the actual market grow as the technology matures In fact these days many large silicon foundries have a MEMS group exploring this promising technology including such giants as INTEL and Motorola Yet MEMS are fundamentally different from microelectronics This means that companies with an established track record in these branches need to adapt their skills whereas companies that want to enter the miniaturization market need to establish an entirely new set of capabilities The same can be said of engineers with classical training who will also need to be educated toward their future professional activity in the MEMS field Here are some questions that a company or technologist may ask I have an existing product with miniaturization market potential Which technology should I adopt What are the manufacturing options available for miniaturization What are the qualitative differences How do we maintain a market lead for products based on MEMS Is there CAD support Can we outsource manufacturing Which skills in our current capability need only adaptation What skills need to be added Professors Jan Korvink and Oliver Paul have set out to answer these questions in a form that addresses the needs of companies commercial practitioners and technologists **Energy Research Abstracts** ,1979

Reviewing **Shape And Thickness Optimization Performance Of A Beam**: Unlocking the Spellbinding Force of Linguistics

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