

## Shape optimization by the homogenization method

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Received July 4, 1995

**Summary.** In the context of shape optimization, we seek minimizers of the sum of the elastic compliance and of the weight of a solid structure under specified loading. This problem is known not to be well-posed, and a relaxed formulation is introduced. Its effect is to allow for microperforated composites as admissible designs. In a two-dimensional setting the relaxed formulation was obtained in [6] with the help of the theory of homogenization and optimal bounds for composite materials. We generalize the result to the three dimensional case. Our contribution is twofold: first, we prove a relaxation theorem, valid in any dimensions; secondly, we introduce a new numerical algorithm for computing optimal designs, complemented with a penalization technique which permits to remove composite designs in the final shape. Since it places no assumption on the number of holes cut within the domain, it can be seen as a topology optimization algorithm. Numerical results are presented for various two and three dimensional problems.

*Mathematics Subject Classification (1991):* 65K10

### 1. Introduction

Shape optimization is a major issue in structural design. One of the most challenging aspects of shape optimization is what structural engineers refer to as the layout, or topology, optimization. Classical methods of shape optimization, based on boundary motion, are ill equipped to capture the possible topological complexity of the shape because the required smoothness assumptions on the boundary of the material domain do not permit hole punching, although it is widely acknowledged that creating holes (*i.e.*, changing the topology) may drastically improve the performance of a candidate optimal shape.

# Shape Optimization By The Homogenization Method

**BM King**



## **Shape Optimization By The Homogenization Method:**

*Shape Optimization by the Homogenization Method* Grégoire Allaire, Eric Bonnetier, Gilles Francfort, François Jouve (auteur en mathématiques.), 1995     **Shape Optimization by the Homogenization Method** Gregoire Allaire, 2012-12-06

The topic of this book is homogenization theory and its applications to optimal design in the conductivity and elasticity settings Its purpose is to give a self contained account of homogenization theory and explain how it applies to solving optimal design problems from both a theoretical and a numerical point of view The application of greatest practical interest targeted by this book is shape and topology optimization in structural design where this approach is known as the homogenization method Shape optimization amounts to finding the optimal shape of a domain that for example would be of maximal conductivity or rigidity under some specified loading conditions possibly with a volume or weight constraint Such a criterion is embodied by an objective function and is computed through the solution of a state equation that is a partial differential equation modeling the conductivity or the elasticity of the structure Apart from those areas where the loads are applied the shape boundary is always assumed to support Neumann boundary conditions i.e. isolating or traction free conditions In such a setting shape optimization has a long history and has been studied by many different methods There is therefore a vast literature in this field and we refer the reader to the following short list of books and references therein 39 42 130 135 149 203 220 225 237 245 258     **Computational Mechanics** M. W. Yuan, 2004     **SHAPE AND LAYOUT OPTIMIZATION USING HOMOGENIZATION METHOD.** Katuyuki Suzuki, 1991 is constrained The same technique is extended to cover cases where multiple load is applied within the given design domain To determine elastic coefficients of structural material with microstructure homogenization theory is used A resizing rule is formulated on the basis of the optimality criteria method

Featured Reviews in Mathematical Reviews 1997-1999 Donald G. Babbitt, Jane E. Kister, 2000-05-05 This second volume of Featured Reviews makes available special detailed reviews of some of the most important mathematical articles and books published from 1997 through 1999 Also included are excellent reviews of several classic books and articles published prior to 1970 Among those reviews for example are the following Homological Algebra by Henri Cartan and Samuel Eilenberg reviewed by G Hochschild Faisceaux algebriques coherents by Jean Pierre Serre reviewed by C Chevalley and On the Theory of General Partial Differential Operators by Lars Hormander reviewed by J L Lions In particular those seeking information on current developments outside their own area of expertise will find the volume very useful By identifying some of the best publications papers and books that have had or are expected to have a significant impact in applied and pure mathematics this volume will serve as a comprehensive guide to important new research across all fields covered by MR     **SIAM Journal on Control and Optimization** Society for Industrial and Applied Mathematics, 2009     *Computational Methods in Engineering & Science* Zhenhan Yao, Mingwu Yuan, 2007-12-31 The 9th EPMESC was successfully held in Macao in November of 2003 At the end of the conference the Board of the EPMESC series decided that the next conference would be

held in a city of the mainland of China Also I was assigned to be the Chair person of the Conference No doubt this is a great honor to me and also a challenge because there are so many professional international conferences in computational mechanics happening frequently in the world After the successful organizing of WCCM6 in Beijing September of 2004 I engaged to organize the 10th EPMESC First of all I had to choose the venue of the Conference After some investigation and a lot of negotiation we went to see the site of the venue in Sanya Hainan Island the south most city in China Finally we made the decision The most important reason for the choice was the ecological environment of this city It is beneficial to our health after hard work We scientists and engineers need a good relaxing place after working hard a place to enjoy life with friends and family Sanya is an ideal place and a real green city Blue sky and white clouds the peaceful sea and the long beach with white sand shells and pearls no pollution and no industry Everything is so beautiful

**Optimal Design through the Sub-Relaxation Method** Pablo Pedregal,2016-09-01 This book provides a comprehensive guide to analyzing and solving optimal design problems in continuous media by means of the so called sub relaxation method Though the underlying ideas are borrowed from other more classical approaches here they are used and organized in a novel way yielding a distinct perspective on how to approach this kind of optimization problems Starting with a discussion of the background motivation the book broadly explains the sub relaxation method in general terms helping readers to grasp from the very beginning the driving idea and where the text is heading In addition to the analytical content of the method it examines practical issues like optimality and numerical approximation Though the primary focus is on the development of the method for the conductivity context the book s final two chapters explore several extensions of the method to other problems as well as formal proofs The text can be used for a graduate course in optimal design even if the method would require some familiarity with the main analytical issues associated with this type of problems This can be addressed with the help of the provided bibliography

*Scientific and Technical Aerospace Reports* ,1992 **Applied Mechanics, Mechatronics, Power Electronics and Infrastructure Engineering** Mykola Surianinov,Pragathi Bellamkonda Rao,Bima Prihasto,Paleerat Wongchampa,Ali Alnaser,Dong Keon Kim,2024-12-30 Special topic volume with invited peer reviewed papers only **Applied Mechanics Reviews** ,2001 **Shape Optimization, Homogenization and Optimal Control** Volker Schulz,Diaraf Seck,2018-09-05 The contributions in this volume give an insight into current research activities in Shape Optimization Homogenization and Optimal Control performed in Africa Germany and internationally Seeds for collaboration can be found in the first four papers in the field of homogenization Modelling and optimal control in partial differential equations is the topic of the next six papers again mixed from Africa and Germany Finally new results in the field of shape optimization are discussed in the final international three papers This workshop held at the AIMS Center Senegal March 13 16 2017 has been supported by the Deutsche Forschungsgemeinschaft DFG and by the African Institute for Mathematical Sciences AIMS in Senegal which is one of six centres of a pan African network of centres of excellence for postgraduate education research and outreach in

mathematical sciences     **Proceedings of the ... ASME Design Engineering Technical Conferences** ,2005

**Homogenization and Structural Topology Optimization** Behrooz Hassani,Ernest Hinton,2012-12-06 Structural topology optimization is a fast growing field that is finding numerous applications in automotive aerospace and mechanical design processes Homogenization is a mathematical theory with applications in several engineering problems that are governed by partial differential equations with rapidly oscillating coefficients Homogenization and Structural Topology Optimization brings the two concepts together and successfully bridges the previously overlooked gap between the mathematical theory and the practical implementation of the homogenization method The book is presented in a unique self teaching style that includes numerous illustrative examples figures and detailed explanations of concepts The text is divided into three parts which maintains the book s reader friendly appeal     **Proceedings of the ... Design Engineering**

**Technical Conferences** ,1995     *Introduction to Optimization Methods and Tools for Multidisciplinary Design in Aeronautics and Turbomachinery* Jacques Periaux,H. Deconinck,2008     [Machinery, Materials Science and Engineering Applications, MMSE2011](#) Quan Jie Gao,2011-04-19 Selected peer reviewed papers from the 2011 International Academic Conference on Machinery Materials Science and Engineering Applications MMSE 2011 July 15 16 2011 Wuhan China

**Abstracts** ,1993     **Proceedings of the ASME Design Engineering Division ...** ,2003     [A Collection of Technical Papers](#) ,1992

Shape Optimization By The Homogenization Method: Bestsellers in 2023 The year 2023 has witnessed a noteworthy surge in literary brilliance, with numerous captivating novels captivating the hearts of readers worldwide. Lets delve into the realm of top-selling books, exploring the captivating narratives that have charmed audiences this year. The Must-Read : Colleen Hoover "It Ends with Us" This poignant tale of love, loss, and resilience has captivated readers with its raw and emotional exploration of domestic abuse. Hoover masterfully weaves a story of hope and healing, reminding us that even in the darkest of times, the human spirit can prevail. Shape Optimization By The Homogenization Method : Taylor Jenkins Reids "The Seven Husbands of Evelyn Hugo" This captivating historical fiction novel unravels the life of Evelyn Hugo, a Hollywood icon who defies expectations and societal norms to pursue her dreams. Reids compelling storytelling and compelling characters transport readers to a bygone era, immersing them in a world of glamour, ambition, and self-discovery. Shape Optimization By The Homogenization Method : Delia Owens "Where the Crawdads Sing" This captivating coming-of-age story follows Kya Clark, a young woman who grows up alone in the marshes of North Carolina. Owens crafts a tale of resilience, survival, and the transformative power of nature, entrancing readers with its evocative prose and mesmerizing setting. These bestselling novels represent just a fraction of the literary treasures that have emerged in 2023. Whether you seek tales of romance, adventure, or personal growth, the world of literature offers an abundance of compelling stories waiting to be discovered. The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts. The Secret History is a brilliant and gripping novel that will keep you guessing until the very end. The novel is a warning tale about the dangers of obsession and the power of evil.

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