

An Investigation of the Recent Developments in Reliability-based Structural Topology Optimization

Muayad Habashneh¹, Majid Movahedi Rad^{1*}

¹ Department of Structural and Geotechnical Engineering, Széchenyi István University, Egyetem tér 1, H-9026 Győr, Hungary

* Corresponding author, e-mail: majidmr@sze.hu

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Abstract

Optimizing a structure's topology involves finding the best possible distribution of material and connections within a given design space. It has a significant effect on its performance, which is why there has been a meteoric rise in the number of articles published on the topic over the last two decades. This work offers an investigation of reliability-based topology optimization of structures, in light of the recent development of several topology optimization techniques for both linear and nonlinear systems. Therefore, the emphasis of this study is on the latest advancements, enhancements, and applications of reliability-based topology optimization. This paper's primary objective is to provide an overview of the latest advancements in the reliability-based topology optimization of structures, with a particular emphasis on the recent improvement of integrating reliability-based design into the bi-directional evolutionary structural optimization (BESO) method, which accounts for the topological optimization of geometric and material nonlinearity as well as thermoelastic problems.

Keywords

topology optimization, reliability-based design, BESO, geometrically nonlinear, elasto-plastic

1 Introduction

The goal of structural optimization is to find the structure that is the lightest, stiffest, strongest, and most frequency-resistant while still meeting certain requirements like volume, mass, and deflection [1]. At the moment, structural optimization can be split into three different subfields: size optimization, topology optimization, and shape optimization [2–4]. It is important to emphasize that the optimization of topology is distinct from the optimization of size and shape. In shape optimization, design variables are the values that determine the shape of the structure of a given topology. Size optimization uses the geometrical dimensions of structural components as design variables, such as the thickness and diameter of a predefined geometrical shape. Topology optimization (TO) finds the ideal material distribution, hole placement, shape, size, and connection in a design domain. It is the most generic structural optimization method and has no constraints on design domain size or boundary, giving engineers greater design flexibility and search space to find the best solution, particularly during early design [5].

In the presence of sources of uncertainty, the optimum performance attained using typical deterministic approaches for structure optimization problems in the actual world might be drastically diminished. Variations in applied loads, material properties, and manufacturing tolerances may be the cause of uncertainty [6–10]. When the uncertainty comes simply from the variable directions in which a load is applied, Csébfalvi [11] offered a novel metaheuristic technique, where the randomness of the load directions were treated as uncertain but constrained parameters. Besides, Csébfalvi [12] presented benchmark results by considering the worst load direction-oriented technique. Kavch and Zaerrega [13] introduced a novel approach for reliability-based design optimization (RBDO) that takes into account unpredictable characteristics like applied loads and material properties. Considering that the suggested technique uses decoupled metaheuristic algorithms. Lógó [14] developed a novel kind of probabilistic optimum topology design approach for continuum-type structures with random load application points.

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Kacprzyk,Valentina Emilia Balas,Vladik Kreinovich,2020-07-10 This book gathers authoritative contributions in the field of Soft Computing Based on selected papers presented at the 7th World Conference on Soft Computing which was held on May 29 31 2018 in Baku Azerbaijan it describes new theoretical advances as well as cutting edge methods and applications New theories and algorithms in fuzzy logic cognitive modeling graph theory and metaheuristics are discussed and applications in data mining social networks control and robotics geoscience biomedicine and industrial management are described This book offers a timely broad snapshot of recent developments including thought provoking trends and challenges that are yielding new research directions in the diverse areas of Soft Computing

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Evaluation of Global Bearing Capacities of Structures G. Sacchi Landriani,J. Salencon,2014-05-04 A synthetic presentation of the theory of yield design is illustrated by examples such as the stability analysis of reinforced soil structures and the resistance of long fiber reinforced composite materials The classical limit analysis theory when standard elastic perfectly plastic behaviour can be assumed yields a more precise assessment of the global bearing capacities of structures and makes optimal limit design possible Structural optimal design is also studied with respect to eigenvalues as well as Structural Topology and Design Optimization

Human-Computer Interaction. Theory, Design, Development and Practice Masaaki Kurosu,2016-07-04 The 3 volume set LNCS 9731 9732 and 9733 constitutes the refereed proceedings of the 18th International Conference on Human Computer Interaction HCII 2016 held in Toronto ON Canada in July 2016 The total of 1287 papers and 186 posters presented

at the HCII 2016 conferences and were carefully reviewed and selected from 4354 submissions The papers thoroughly cover the entire field of Human Computer Interaction addressing major advances in knowledge and effective use of computers in a variety of application areas The volumes constituting the full 27 volume set of the conference proceedings **New Developments in Contact Problems** Peter Wriggers, Panagiotis Panatiotopoulos, 2014-05-04 The book gives an overview on formulation mathematical analysis and numerical solution procedures of contact problems In this respect the book should be of value to applied mathematicians and engineers who are concerned with contact mechanics **Applied Mechanics Reviews**, 1974 Intelligent Computational Paradigms in Earthquake Engineering Nikos D. Lagaros, Yiannis Tsompanakis, 2007-01-01 This book contains contributions that cover a wide spectrum of very important real world engineering problems and explores the implementation of neural networks for the representation of structural responses in earthquake engineering It assesses the efficiency of seismic design procedures and describes the latest findings in intelligent optimal control systems and their applications in structural engineering Provided by publisher Recent Advances in Optimal Structural Design Scott A. Burns, 2002-01-01 Sponsored by the Technical Committee on Structural Design of the Technical Administrative Committee on Analysis and Computation of the Technical Activities Division of the Structural Engineering Institute of ASCE This report documents the dramatic new developments in the field of structural optimization over the last two decades Changes in both computational techniques and applications can be seen by developments in computational methods and solution algorithms the role of optimization during the various stages of structural design and the stochastic nature of design in relation to structural optimization Topics include methods for discrete variable structural optimization decomposition methods in structural optimization state of the art on the use of genetic algorithms in design of steel structures conceptual design optimization of engineering structures topology and geometry optimization of trusses and frames evolutionary structural optimization design and optimization of semi rigid framed structures optimized performance based design for buildings multi objective optimum design of seismic resistant structures and reliability and cost oriented optimal bridge maintenance planning The book concludes with an extensive bibliography of journal papers on structural optimization published between 1987 and 1999 **Analytic Methods for Design Practice** Gyung-Jin Park, 2007-02-15 In the world of modern engineering rigorous and definite design methodologies are needed However many parts of engineering design are performed in either an ad hoc manner or based on the intuition of the engineer This is the first book to look at both stages of the design process conceptual design and detailed design and detail design methodologies for every step of the design process Case studies show how practical design problems can be solved with analytic design methods This book is an excellent introduction to the subject The book s practical focus will make the book useful to practicing engineers as a practical handbook of design **Simulation-Driven Design by Knowledge-Based Response Correction Techniques** Slawomir Koziel, Leifur Leifsson, 2016-05-13 Focused on efficient simulation driven multi fidelity optimization techniques this

monograph on simulation driven optimization covers simulations utilizing physics based low fidelity models often based on coarse discretization simulations or other types of simplified physics representations such as analytical models The methods presented in the book exploit as much as possible any knowledge about the system or device of interest embedded in the low fidelity model with the purpose of reducing the computational overhead of the design process Most of the techniques described in the book are of response correction type and can be split into parametric usually based on analytical formulas and non parametric i e not based on analytical formulas The latter while more complex in implementation tend to be more efficient The book presents a general formulation of response correction techniques as well as a number of specific methods including those based on correcting the low fidelity model response output space mapping manifold mapping adaptive response correction and shape preserving response prediction as well as on suitable modification of design specifications Detailed formulations application examples and the discussion of advantages and disadvantages of these techniques are also included The book demonstrates the use of the discussed techniques for solving real world engineering design problems including applications in microwave engineering antenna design and aero hydrodynamics

New Developments in Mining Engineering 2015 Genadiy Pivnyak, Volodymyr Bondarenko, Iryna Kovalevska, 2015-10-14 This annual series of books includes scientific papers on mining profiles This volume presents multiple aspects of mining technology implementation in several aspects extraction of coal iron manganese uranium and other ores Capturing and utilization of coalbed methane by various methods including alternative ones safety measures in mining ecological aspects etc Specific attention is paid to intensification of mineral resources extraction processes by way of modernizing opening methods development and mining methods depending on mining geological conditions Experimental results of stress strain state rock massif forecast by means of computational experiments using recursive methods are also discussed Any mining operations should finally result in adequate recovery of land surface and utilization of mining wastes using various environmentally friendly methods thus sufficient attention is paid to this scientific trend Non traditional methods of minerals mining are becoming more topical and of higher demand in the modern society Hence several papers chapters are devoted to underground coal gasification and its subsequent processes In addition extraction technologies of gas hydrate as a source of an abundant amount of natural gas are thoroughly examined in this book including implementation of gas hydrate technologies for mine methane utilizations with its following transportation in a solid state Furthermore attention is given to evaluation of economic efficiency of minerals mining by the proposed methods their ways of enrichment ecological aspects and the influence of mining production on the environment innovational logistic solutions at mining enterprises and also to perspectives of Ukraine s mining industry integration to the European standards

Reanalysis of Structures Uri Kirsch, 2008-02-24 This book deals with various computational procedures for multiple repeated analyses reanalysis of structures and presents them in a unified approach It meets the need for a general text covering the basic concepts and methods as well as recent developments in this area To

clarify the presentation many illustrative examples and numerical results are demonstrated Previous books on structural analysis do not cover most of the material presented here

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Table of Contents Recent Developments In Structural Optimization

1. Understanding the eBook Recent Developments In Structural Optimization
 - The Rise of Digital Reading Recent Developments In Structural Optimization
 - Advantages of eBooks Over Traditional Books
2. Identifying Recent Developments In Structural Optimization
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Recent Developments In Structural Optimization
 - User-Friendly Interface
4. Exploring eBook Recommendations from Recent Developments In Structural Optimization
 - Personalized Recommendations
 - Recent Developments In Structural Optimization User Reviews and Ratings
 - Recent Developments In Structural Optimization and Bestseller Lists

5. Accessing Recent Developments In Structural Optimization Free and Paid eBooks
 - Recent Developments In Structural Optimization Public Domain eBooks
 - Recent Developments In Structural Optimization eBook Subscription Services
 - Recent Developments In Structural Optimization Budget-Friendly Options
6. Navigating Recent Developments In Structural Optimization eBook Formats
 - ePub, PDF, MOBI, and More
 - Recent Developments In Structural Optimization Compatibility with Devices
 - Recent Developments In Structural Optimization Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Recent Developments In Structural Optimization
 - Highlighting and Note-Taking Recent Developments In Structural Optimization
 - Interactive Elements Recent Developments In Structural Optimization
8. Staying Engaged with Recent Developments In Structural Optimization
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Recent Developments In Structural Optimization
9. Balancing eBooks and Physical Books Recent Developments In Structural Optimization
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Recent Developments In Structural Optimization
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Recent Developments In Structural Optimization
 - Setting Reading Goals Recent Developments In Structural Optimization
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Recent Developments In Structural Optimization
 - Fact-Checking eBook Content of Recent Developments In Structural Optimization
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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