

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. Kaveh and Zaerreza [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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knowledge and effective use of computers in a variety of application areas The volumes constituting the full 27 volume set of the conference proceedings

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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

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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

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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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Cheng Yu, 2023-11-04 Recent Trends in Cold Formed Steel Construction Second Edition focuses on the application and use of this important construction material. In this updated edition, new chapters take on these developments, offering updates on cutting edge new technologies and design methods for using cold formed steel as a structural material and providing technical guidance on how to design and build sustainable and energy efficient cold formed steel buildings. Sections introduce codes, specifications and design methods, provide computational analysis of cold formed steel structures, examine the structural performance of cold formed steel buildings and review thermal performance, acoustic performance, fire protection, floor vibrations and blast resistance. Over the last few years, there have been major breakthroughs for cold formed steel design with modular building applications now becoming more widely accepted. Other scientific developments include research on system reliability, applications of AI, machine learning and the use of high strength steel as well as new connection methods and changes in DSM codes. Addresses building science issues and provides performance solutions for the design of cold formed steel buildings. Provides guidance for using next generation design methods, computational tools and technologies. Edited by an experienced researcher and educator with significant knowledge on new developments in cold formed steel construction. Covers new developments such as modular construction, machine learning and code developments in Europe, Australia and China.

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