

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

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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.

Recent Developments In Structural Optimization

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Recent Developments in Structural Optimization Structures Congress,1986 *Recent Developments in Structural Optimization* Franklin Y. Cheng,1986 **New Developments in Displacement Based Multilevel Structural Optimization** Craig L. Plunkett,2000 *New Developments in Structural Optimization Using Optimality Criteria* Torben Birker,1996 Structural Optimization Ovadia E. Lev,1981 **Applied Mechanics Reviews** ,1989 **Design-Oriented Analysis of Structures** Uri Kirsch,2006-04-11 This book was developed while I was teaching graduate courses on analysis design and optimization of structures in the United States Europe and Israel Structural analysis is a main part of any design problem and the analysis often must be repeated many times during the design process Much work has been done on design oriented analysis of structures recently and many studies have been published The purpose of the book is to collect together selected topics of this literature and to present 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 This should prove useful to students researchers consultants and practicing engineers involved in analysis and design of structures Previous books on structural analysis do not cover most of the material presented in the book The book deals with the problem of multiple repeated analyses reanalysis of structures that is common to numerous analysis and design tasks Reanalysis is needed in many areas such as structural optimization analysis of damaged structures nonlinear analysis probabilistic analysis controlled structures smart structures and adaptive structures It is related to a wide range of applications in such fields as Aerospace Engineering Civil Engineering Mechanical Engineering and Naval Architecture *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 **Structural Optimization** Uri Kirsch,2012-12-06 This book was developed while teaching a graduate course at several universities in the United States Europe and Israel during the last two decades The purpose of the book is

to introduce the fundamentals and applications of optimum structural design Much work has been done in this area recently and many studies have been published The book is an attempt to collect together selected topics of this literature and to present them in a unified approach It meets the need for an introductory text covering the basic concepts of modern structural optimization A previous book by the author on this subject Optimum Structural Design published by McGraw Hill New York in 1981 and by Maruzen Tokyo in 1983 has been used extensively as a text in many universities throughout the world The present book reflects the rapid progress and recent developments in this area A major difficulty in studying structural optimization is that integration of concepts used in several areas such as structural analysis numerical optimization and engineering design is necessary in order to solve a specific problem To facilitate the study of these topics the book discusses in detail alternative problem formulations the fundamentals of different optimization methods and various considerations related to structural design The advantages and the limitations of the presented approaches are illustrated by numerous examples

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Advances in Structural Engineering—Optimization Sinan Melih Nigdeli, Gebrail Bekdaş, Aylin Ece Kayabekir, Melda Yucel, 2020-12-04 This book is an up to date source for computation applications of optimization prediction via artificial intelligence methods and evaluation of metaheuristic algorithm with different structural applications As the current interest of researcher metaheuristic algorithms are a high interest topic area since advance and non optimized problems via mathematical methods are challenged by the development of advance and modified algorithms The artificial intelligence AI area is also important in predicting optimum results by skipping long iterative optimization processes The machine learning used in generation of AI models also needs optimum results of metaheuristic based approaches This book is a great source to researcher graduate students and bachelor students who gain project about structural optimization Differently from the academic use the chapter that emphasizes different scopes and methods can take the interest and help engineer working in design and production of structural engineering projects

Topology Design Methods for Structural Optimization

Oswaldo M. Querin, Mariano Victoria, Cristina Alonso Gordo, Rubén Ansola, Pascual Martí, 2017-06-09 Topology Design Methods for Structural Optimization provides engineers with a basic set of design tools for the development of 2D and 3D structures subjected to single and multi load cases and experiencing linear elastic conditions Written by an expert team who has collaborated over the past decade to develop the methods presented the book discusses essential theories with clear guidelines on how to use them Case studies and worked industry examples are included throughout to illustrate practical applications of topology design tools to achieve innovative structural solutions The text is intended for professionals who are interested in using the tools provided but does not require in depth theoretical knowledge It is ideal for researchers who want to expand the methods presented to new applications and includes a companion website with related tools to assist in further study Provides design tools and methods for innovative structural design focusing on the essential theory Includes case studies and real life examples to illustrate practical application challenges and solutions Features accompanying software on a companion website to allow users to get up and running fast with the methods introduced Includes input from an expert team who has collaborated over the past decade to develop the methods presented

Abstract Journal in Earthquake Engineering ,1987

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