Accepted Manuscript

Risk averse stochastic structural topology optimization

Martin Eigel, Johannes Neumann, Reinhold Schneider, Sebastian Wolf

PII: S0045-7825(18)30074-4
DOI: https://doi.org/10.1016/j.cma.2018.02.003
Reference: CMA 11778

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date : 23 August 2017
Revised date : 31 January 2018
Accepted date : 1 February 2018

Please cite this article as: M. Eigel, J. Neumann, R. Schneider, S. Wolf, Risk averse stochastic structural topology optimization, *Comput. Methods Appl. Mech. Engrg.* (2018), https://doi.org/10.1016/j.cma.2018.02.003

RISK AVERSE STOCHASTIC STRUCTURAL TOPOLOGY OPTIMIZATION

MARTIN EIGEL, JOHANNES NEUMANN, REINHOLD SCHNEIDER, AND SEBASTIAN WOLF

Abstract. A novel approach for risk-averse structural topology optimization under uncertainties is presented, which takes into account stochastic data of the state equation, specifically random material properties and random forces. For the distribution of material, a phase field approach is employed, which allows for arbitrary topological changes during the iterative optimization. The state equation is assumed to be a high-dimensional PDE parametrized in a (truncated finite) set of random variables. The examined case employs linearized elasticity with a parametric elasticity tensor.

For practical purposes, instead of an optimization with respect to the expectation of the involved random fields, the designed structures should in particular be robust with respect to rather unlikely and possibly critical events. For this, as a common risk measure, the Conditional Value at Risk (CVaR), is introduced to the cost functional of the minimization procedure. The proposed method is illustrated with numerical examples based on Monte Carlo sampling for different risk values and compared with the result of the deterministic formulation. It is observed that the resulting shapes dependent on the risk parameter of the functional and can deviate significantly from the deterministic case.

1. Introduction

This work is concerned with structural topology optimization subject to a high-dimensional parametric state equation. The parameter dependence originates from a parametric description of the randomness of the model data. The general goal is to determine an optimal distribution of a limited amount of material in some design domain, such that an objective functional is minimized, see e.g. [1–3]. As an example, one may think of the task to determine the optimal design (with respect

Date: January 31, 2018.

2010 *Mathematics Subject Classification.* 35R60, 47B80, 60H35, 65C20, 65N12, 65N22, 65J10.

Key words and phrases. partial differential equations with random coefficients, risk averse optimization, phase field, topology optimization, conditional value at risk, uncertainty quantification, stochastic finite element methods, operator equations, adaptive methods.

Research of J. Neumann was funded in part by the DFG Matheon project SE13. Research of S. Wolf was funded in part by the DFG Matheon project D-SE10.