Accepted Manuscript

Stiffness optimization of non-linear elastic structures

Mathias Wallin, Niklas Ivarsson, Daniel Tortorelli

PII: S0045-7825(17)30708-9
DOI: https://doi.org/10.1016/j.cma.2017.11.004
Reference: CMA 11663

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

Received date : 24 May 2017
Revised date : 30 October 2017
Accepted date : 2 November 2017

Please cite this article as: M. Wallin, N. Ivarsson, D. Tortorelli, Stiffness optimization of non-linear elastic structures, *Comput. Methods Appl. Mech. Engrg.* (2017), https://doi.org/10.1016/j.cma.2017.11.004

Stiffness optimization of non-linear elastic structures

Mathias Wallin[a,*], Niklas Ivarsson[a], Daniel Tortorelli[b]

[a]Division of Solid Mechanics, Lund University, Box 118, SE-22100 Lund, Sweden
[b] Center for Design and Optimization, Lawrence Livermore National Laboratory, Livermore, CA, USA

Abstract

This paper revisits stiffness optimization of non-linear elastic structures. Due to the non-linearity, several possible stiffness measures can be identified and in this work conventional compliance, i.e. secant stiffness designs are compared to tangent stiffness designs. The optimization problem is solved by the method of moving asymptotes and the sensitivities are calculated using the adjoint method. For the tangent cost function it is shown that although the objective involves the third derivative of the strain energy an efficient formulation for calculating the sensitivity can be obtained. Loss of convergence due to large deformations in void regions is addressed by using a fictitious strain energy such that small strain linear elasticity is approached in the void regions. A well posed topology optimization problem is formulated by using restriction which is achieved via a Helmholtz type filter. The numerical examples provided show that for low load levels, the designs obtained from the different stiffness measures coincide whereas for large deformations significant differences are observed.

Keywords: Topology optimization, stiffness optimization, finite strains, non-linear elasticity

1. Introduction

Topology optimization has rapidly evolved and is now widely used in industry to create new innovative structural designs. The method is frequently used in the early design phase to find appropriate load paths wherein the goal is usually related to stiffness maximization as opposed to e.g. stress optimization, cf. [1]. The vast majority of the research on topology optimization is restricted to structures which operate in the linear regime, i.e. the deformations are assumed to be small and the material response linear. For an overview of the method and areas of applications see [2]. To increase the range of applicability of the method, other cost functions and non-linear response should be considered.

For linear structures, the definition of the stiffness is well-defined since the tangent of the load-displacement response is independent of the load level, cf. Fig. 1a. However,

*Division of Solid Mechanics, Lund University, Box 118, SE-22100 Lund, Sweden. E-mail: mathias.wallin@solid.lth.se