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Topology Optimization of Discrete/Discretized Structures: On Limiting Displacements in Designs with Singular Stiffness Matrix and Some Implications on Optimality Conditions

Wolfgang Achtziger[1]

[1] Friedrich-Alexander University, Germany

Abstract

We consider problem formulations in the field of topology optimization of discretized structures (i.e., after FE discretization) or of discrete structures (like trusses). The focus lies on formulations of simultaneous analysis and design (SAND) without lower bounds on the design variables. One reason for these considerations are investigations of well-known misbehaviour of standard numerical optimization algorithms due to the violation of standard regularity properties in the theory of optimality conditions. Another reason is the question of approximative correctness of calculated solutions in problem formulations using positive lower bounds as, e.g., in approaches of nested analysis and design (NAND). Although this class of approaches is the standard in topology optimization, for the big majority of problem formulations the behaviour of optimal solutions is still unclear for lower bounds tending to zero.

It turns out that many open theoretical and practical questions in this area could be answered if the limiting behaviour of displacements for void structural elements was mathematically transparent. Of course, all difficulties are caused by the stiffness matrix becoming singular in the limit.

This talk presents the outcome of some investigations on the relation between design and state variables for designs with singular stiffness matrix in the limit. New results show that, under certain conditions, limiting displacements exist depending on the sequence of the limiting design. Based on these results we investigate standard first order optimality conditions for simple classical SAND design problem formulations. As a result we conclude that these conditions hold for minimum volume and minimum compliance problems (among others). The results in this talk are based on joint work with Christoph Schürhoff.