ON GLOBALLY STABLE SINGULAR TRUSS TOPOLOGIES

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We consider truss topology optimization problems including a global stability constraint, which guarantees a sufficient elastic stability of the optimal structure. Linear buckling assumptions are assumed to hold for the truss under consideration, allowing us to reduce the global stability requirement to a nonlinear matrix inequality [1]. The resulting problem is therefore a nonconvex semidefinite program, for which the nonconvex interior point methods are known to show the best performance.

We demonstrate that in the framework of topology optimization the global stability constraint may behave similarly to stress constraints, that is, some globally optimal solutions are singular and cannot be approximated from the interior of the design domain. This behaviour, which may be referred to as a "global stability singularity" phenomenon, prevents the convergence of interior point methods towards the globally optimal solutions. We propose a simple relaxation strategy, which restores the regularity of the design domain. (To each relaxed problem the interior point method can then be applied.)

A further goal is to address the lack of bounds on the maximal allowable stresses in structural members in the global stability constraned problem introduced in [1]. This simplified formulation stems from the tractability considerations as well as from the experience that it is often the insufficient elastic stability and not the overstressed members that lead to structural failures (cf. [1] and references therein). However, two independent studies show that neither do the stress constraints guarantee global stability [2], nor vice versa [3]; these studies suggest that both types of constraints should be treated simultaneously. Since the singular behaviour of stress and global stability constraints are similar, we can also design a numerical scheme capable of handling both types of constraints.

Finally, we discuss an alternative (extended) formulation of the problem (cf. [4]). Both approaches are illustrated with numerical examples.

References

[1] M. Kočvara, "On the Modelling and Solving of the Truss Design Problem with Global Stability Constraints", *Structural and Multidisciplinary Optimization*, v. 23, pp. 189–203, 2002.
[2] G. I. N. Rozvany, "Difficulties in topology optimization with stress, local buckling and system stability constraints", *Structural Optimization*, v. 11, pp. 213–217, 1996.
[3] R. Sedaghati, and B. Tabarrok, "Optimum Design of Truss Structures Undergoing Large Deflections Subject to a System Stability Constraint", *International Journal for Numerical Methods in Engineering*, v. 48, pp. 421–434, 2000.
[4] M. Stolpe, and K. Svanberg, "A note on stress-constrained truss topology optimization", *Structural and Multidisciplinary Optimization*, v. 25, pp. 62-64, 2003.