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# Eigenvalue buckling analysis in Topology Optimization via a NURBS-framed algorithm

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This work focuses on the most relevant aspects of considering eigenvalue buckling analyses in the framework of a NURBS-based Topology Optimization (TO) algorithm applied to 2D thin-walled structures. The fictitious density describing the topology in classic SIMP approaches [1] is defined as a NURBS surface [2] in the proposed procedure. This technique allows the designer to benefit from two main advantages. On the one hand, the NURBS formulation implies new sets of design variables (i.e., the NURBS control points and weights) and this fact permits to exploit an implicitly defined filter zone (checkerboard effects are automatically avoided), significantly reducing the number of design variables. On the other hand, a geometric CAD-compatible entity is defined over the computational domain and can be used to straightforwardly retain the smooth boundaries of the optimised 2D structure [3]. Since TO allows for obtaining performing and slender structures, which can undergo buckling phenomena, there is a true interest in taking into account buckling in TO, either as objective or as constraint function [1]. In this study, only linear modelling is considered: buckling loads are the eigenvalues and the corresponding modes are the eigenvectors of the standard buckling formulation, involving the global stiffness matrix and the stress stiffness matrix. In this framework, some issues arise: firstly, the sensitivity analysis of buckling loads (for each mode) needs to be computed with respect to the new sets of design variables; secondly, performing the optimization, it is possible the structure exhibits small buckling loads corresponding to meaningless pseudo-modes in low density regions; finally, the optimization problem should be carefully formulated in order to avoid the so-called "mode-switching": the *(k+1)th* mode could become more critical than the *kth* mode and, in this case, the objective or constraint functions could undergo a discontinuity, that is harmful in a gradient-based optimization strategy. A solution of these problems is proposed herein: the sensitivity analysis is computed by means of an energetic approach and the computation of the stress stiffness matrix is avoided; the problem of the pseudo-modes is solved by suitably selecting the actual active modes through the smart techniques proposed in [4]. This work contributes to improve the effectiveness of the NURBS-based SIMP method.

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