Compliance based column topologies generated for maximal buckling load

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Topology optimization of structures exposed to loss of stability rarely appears in the literature, hence the number of publications dealing with this subject is rather modest. This also applies to topology optimization of vibrating elements. From among papers discussing this issue one can point out for example Cheng et al (Proceedings of the Fourth International Conference on High Performance Computing in the Asia-Pacific Region, 2000) or Du and Olhoff (Structural and Multidisciplinary Optimization, 2007).

In this paper, the problem of topology optimization of columns against instability is formulated in a manner allowing to solve it with Cellular Automata (CA) method. It is worth noting that CA approach to structural optimization by nature requires local formulation of the design problem, and therefore it is not straightforward how to apply it to maximization of a structure buckling load, which is a global quantity. Fortunately one can for example observe that for the optimal column, for which critical load has been maximized, the maximal bending stress is uniformly distributed along column axis. Taking that into account it is possible to replace conventional maximization of buckling load by a problem formulated as the fully stressed design. This concept was presented in Bochenek and Tajs-Zielińska (Engineering Optimization, 2012). where the locally formulated problem of optimal sizing of columns prone to instability was considered.

Based on the above observation another locally formulated problem is proposed to be applied for maximization of global buckling load. The concept is as follows. First the standard instability analysis of a compressed column is performed and buckling mode is determined. Then the compressive loading is replaced by a transverse one which is selected so as to generate bending moment, distribution of which coincides with the deflection function representing particular buckling mode. For the bent structure minimization of compliance is performed, and optimal topology is generated. Finally the critical load for the optimal column is calculated. This critical load is much higher as compared to a prismatic column of the same volume. It should be also stressed that critical load obtained for the column of optimal topology is also higher than the one found for a column for which the standard approach of optimal sizing against buckling has been applied.

The efficient update rules of CA have been implemented into the algorithm which generates optimal topologies. The two and three dimensional design models have been taken into account and the performance of the numerical algorithm based on the presented concept is discussed.