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CONSIDERING LINEAR BUCKLING FOR 3D DENSITY BASED TOPOLOGY OPTIMIZATION

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Abstract: Stability is an important issue in topology optimization, since results of the optimization are often framework structures. If some trusses of these structures are subjected to compression, they maybe buckle and the structure fails. Since Neves et al., Rahmatalla and Swan as well as Bendsøe and Sigmund demonstrated the use of linear buckling as structure response for the density method, this application was not improved significantly. Their problems were -they used a material interpolation scheme, which was not continuously differentiable, so that a smooth convergence was not ensured (Neves et al.). -they have not treated spurious modes, which are buckling modes in low density regions (Rahmatalla and Swan). -they have not considered or not allowed mode switching (Neves et al., Rahmatalla and Swan, Bendsøe and Sigmund). The first buckling mode of the initial design does not need to be the first buckling mode of the optimized design. During the optimization other modes can be become the critical one. -they have not considered duplicated eigenvalues (Neves et al., Rahmatalla and Swan). If two eigenvalues are the same, their sensitivities cannot be calculated separately. and for all of them the lack of computing power to show realistic 3D applications. In this contribution a continuously differentiable material interpolation scheme is explained to avoid spurious modes. It is shown how to cope with several modes (mode switching, duplicated eigenvalues) and how to use buckling safety as objective or constraint. The optimized structures are compared with results for compliance design. It is shown, that it is not useful to use buckling and mass as the only structure responses, because substructures subjected to tension can become very thin without a negative influence on the buckling safety. Thus tensile stresses are not limited. Buckling and mass have to be combined with other structure responses, like stress or compliance, to achieve a useful structure. Also the combination with manufacturing constraints for deep drawing, as shown by Dienemann et al., is discussed in this contribution. Therefore 3D structures with up to a million design variables are presented. Neves MM, Rodrigues H, Guedes JM(1995) Generalized topology design of structures with a buckling load criterion. StructOptim10:71–78 Rahmatalla S, Swan CC(2003) Form Finding of Sparse Structures with Continuum Topology Optimization. JStructEng129:1707–1716 Bendsøe MP, Sigmund O(2004) Topology Optimization: Theory, Methods and Applications. Springer Dienemann R, Schumacher A, Fiebig S(2017) Topology optimization for finding shell structures manufactured by deep drawing. StructMultidiscipOptim56:473–485