An efficient method for topology optimization with prescribed safety margin

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To solve the problem of reliability-based topological optimization, a heuristic algorithm was used, consisting in removing redundant material in the areas with the lowest stress intensity. In this algorithm, the design variables represent the material densities in the individual finite elements. The material is removed by reducing the density of finite elements as a function of the stress intensity.

A side effect of the optimization process is a reduction in the safety of the structure. This is especially important in topological optimization where the process requires material removal [1]. Providing a safety margin consists in introducing additional constraints related to the probability of failure to the formulation of the optimization problem. This means that the probability of failure will not be greater than the explicitly indicated value.

However, adding a reliability analysis to the optimization process can significantly increase its computational effort and therefore, the use of efficient methods to determine the failure probability becomes a key issue [2]. The low probability of failure, which should characterize a safely designed structure, can be estimated with sufficient accuracy by applying first-order methods. This approach is based on the assumption that the objective function can be linearly approximated in the vicinity of the design point. A large number of algorithms based on first-order assumption has been developed for the evaluation of reliability constraints, among which Reliability Index Approach (RIA) and Performance Measure Approach (PMA) are most frequently used. The latter approach is characterized by better numerical efficiency and stability.

The effectiveness of the proposed methodology will be illustrated with several numerical examples. The originally developed computer program written in MATLAB environment [3] will also be briefly presented.

[1] Błachowski B., Tauzowski P., Lógó J., *Yield limited optimal topology design of elastoplastic structures*, **Structural and Multidisciplinary Optimization**, DOI: 10.1007/s00158-019-02447-9, pp.1-24, 2020

[2] Tauzowski P., Błachowski B., Lógó J., *Topology optimization of elasto-plastic structures under reliability constraints: a first order approach*, **Computers and Structures**, DOI: 10.1016/j.compstruc.2020.106406, Vol.243, pp.106406-1-15, 2021

[3] Tauzowski P., Błachowski B., Lógó J., *Functor-oriented topology optimization of elasto-plastic structures*, **Advances in Engineering Software**, DOI: 10.1016/j.advengsoft.2019.102690, Vol.135, pp.102690-1-11, 2019