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ELASTO-PLASTIC TOPOLOGY OPTIMIZATION UNDER STOCHASTIC LOADING CONDITIONS

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Abstract: Advances in 3D printing technology make that structural optimization attracts recently a lot of attention in many research and scientific centers around the world. Nowadays, researchers' efforts are oriented rather towards structural topology optimization under deterministic forces with single load conditions, however the design is based on linearly or nonlinearly elastic material. The last two issues are critical in engineering practice since many deterministic optimal solutions are very sensitive to changes in loading conditions and multiple loading conditions are more realistic. As it is known the multiple loading conditions and the stochastic loading can lead for the same surrogate model. For that reason topology optimization of the structures subjected to stochastic loading is one part of the current research topic. Another issue is related to material properties, which often have to take into consideration plastic characteristics of the applied materials and the load carrying capacity is limited. A practical method for topology optimization of elastoplastic structures has been proposed by the authors recently. One of the major advantages of the method is its straightforward applicability to real engineering problems. Instead of traditionally used structural weight minimization subjected to compliance constraint in our method constraints are imposed directly on stresses. The purpose of the present study is to extend this method to the case of elasto-plastic topology optimization with some probabilistic constraints. To this end, we assume that external loading acting on the structural system under consideration is having stochastic nature, defined by its distribution type, mean value and standard deviation. With the aim of our method the above problem is solved in a way, which assures safety of the structures with given probability value. Although in the past there were some attempts to solve the above mentioned problems analytically, they concerned rather simple academic examples. The approach applied in the present study fully relies on computational methods in particular Finite Element (FE) method and reliability methodology such as FORM, SORM or Monte Carlo. Additionally since the number of FE analyses required to obtain optimal solution is enormous, some aspects of multi-core computing will be discussed. The effectiveness of the proposed stochastic/elasto-plastic topology optimization method will be demonstrated on benchmark problems including cantilever structure and simply supported beam. Moreover, both structural systems will be represented by plane stress finite elements and they will be subjected to stochastic load and linearly elastic-perfectly plastic material.