LEAST WEIGHT STRUCTURES AND LEAST COMPLIANT BODIES. OPTIMAL LAYOUT PROBLEMS AND RECOVERY OF UNDERLYING MICROSTRUCTURE

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The contemporary methods of 3D printing make it possible to produce structural elements of shapes and microstructural characteristics ideally suited for the predicted applications. The most essential criterion is to adjust the compliance to the predicted loading. The problem of minimization of the compliance of linear elastic structures may be solved by using the stress-based formulation which makes it possible to perform explicitly minimization over the design parameters (stiffnesses or elastic moduli) and reduce the problem to an auxiliary problem of mathematical structure of optimum transshipping. The latter problem involves a statically admissible stress field; the unknown stress field minimizes the given functional with the integrand expressed by a certain norm (or a gauge). Due to the linear growth of the functional of the auxiliary problem its minimizer vanishes on a sub-domain of the given design domain thus determining the place where the material (or the structural members) is not necessary. The optimal structure is formed in the effective domain of the minimizer. The above scheme applies both to the classical Michell problem (see Ch. 3-5 in Ref.[1]) as well as to the material optimization problems corresponding to designing: a) anisotropy(AMD), cubic symmetry (CMD), c) isotropy(IMD) with two independent moduli, d) Young's modulus design (YMD), see Ch. 7.2 in Ref.[1]. Extensions towards multi-load cases are possible, see Ref.[2]. The stress field being the mentioned minimizer determines the optimal moduli of anisotropy of the optimal structure, yet does not deliver any information on the underlying microstructure. The lecture will discuss the available methods of recovery of optimal isotropic and cubic microstructures with a special emphasis put on the auxetic microstructures, see Ref.[3].

The second part of the lecture concerns optimum design of roofs composed of arches subjected to transmissible vertical loads. The variational setting of the theory of Prager-Rozvany archgrids has been recently put forward in Ch.6 of Ref.[1]. The roofs are formed of arches going in two orthogonal directions. This setting will be extended and illustrated by new designs of optimal roofs spanned over non-convex and multi-connected domains. The designs will be compared with 3D Michell structures corresponding to transmissible loads, obtained with using new adaptive versions of the ground structure method.

References

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