S. Czarnecki, T. Lewiński, On material design by the optimal choice of Young's modulus distribution,
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Abstract
This paper concerns the problem of optimal distribution of Young's modulus within an elastic and isotropic body with prescribed, not necessarily uniform, distribution of Poisson's ratio. The merit function is the total compliance corresponding to a given single load case. The unit cost of the design is assumed as the trace of Hooke's tensor, which is proportional to Young's modulus here. The problem thus formulated is a constrained version of the isotropic material design problem, in which both bulk and shear elastic moduli of isotropy are design variables. In contrast to the latter approach, the optimal material is either nonsingular or degenerates to a void. The optimal distribution of Young's modulus is determined by a solution to an auxiliary minimization problem with the integrand of linear growth. The problem dual to the latter assumes the form similar to that known from the theory of Michell trusses. The proposed numerical approach focuses on solving the former auxiliary problem. The case studies comprise selected optimal designs corresponding to the isotropic material optimization and Young's modulus optimization developed in this paper. The exemplary optimal solutions show that admitting negative values of Poisson's ratio may contribute to a decrease of the total compliance, thus leading to better designs.