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Application of the Material Force Method to Structural Optimization

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The present contribution aims at deriving a variationally consistent strategy to generate truss structures which are optimal in the sense of energy minimization. Accordingly, not only the spatial node point positions of the individual truss members, but also their material node point positions, i.e. the truss geometry itself, are introduced as primary unknowns. The governing equations follow straightforwardly from the Dirichlet principle for conservative mechanical systems. Thereby, the central idea is the reformulation of the total variation of the potential energy at fixed referential coordinates in terms of its variation at fixed material and at fixed spatial coordinates. The corresponding Euler–Lagrange equations define the spatial and the material motion version of the balance of linear momentum, i.e. the balance of spatial and material forces, in a consistent dual format. The suggested algorithm is then essentially characterized through the discretization and simultaneous solution of both, the spatial and the material motion problem. In this sense, the proposed strategy can be interpreted as a variational ALE formulation which renders not only the deformed truss structure but also an improvement of the node point positions themselves. The suggested algorithm will be discussed by means of illustrative examples.

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