The Stiffness Spreading Method in Integrated Layout Optimization Design for Multi-component Structural Systems

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Abstract: In this paper, the stiffness spreading method (SSM), which was previously proposed for layout design of truss structures, is implemented to solve integrated layout optimization design problems. In the proposed model, discrete components, bars or solid elastic bodies, together with the continuous supporting structures are optimized simultaneously. The design variables are the locations and the sizes of the discrete components and the topology of the continuous supporting structure. With the SSM, the stiffness contribution of a discrete component can be approximated and extended to a background mesh with the radial basis functions (RBF) interpolation approach. The background mesh of the supporting structure can be inconsistent with the mesh of the discrete components, thus there is no need to remesh for finite element analysis when the locations of the discrete components change during the optimization process. Furthermore, the sensitivities required for the optimization design can be obtained analytically and high efficient mathematical programming algorithms, such as the Method of Moving Asymptotes (MMA), can be easily implemented into this model. The method of solid isotropic microstructure with penalization (SIMP) is applied for the optimization of the continuous supporting structure in this paper, but other models such as level set method (LSM) can also be implemented without any difficulty. Based on the proposed model, several mean compliance minimization problems are studied, and numerical examples illustrate the feasibility of the proposed method.

Keywords: Structural optimization, Topological optimization, Integrated layout design, Radial basis functions