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Structural optimization of standardized trusses by dynamic grouping of modules

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Abstract

Modular structures tend to be widely used in civil engineering since components can be mass-produced in high quality controlled facilities, leading to economy of construction and improved reliability. Existing research in optimization of modular structures has focused primarily on the notion of modularity where only the topology is repeated [1].

This paper presents a novel approach for dynamic grouping and topology optimization of modular structures, including the spatial orientation of the modules as an additional design variable. This extends the standard notion of modularity by accounting for the topology invariance of the module under rigid body rotations. Group theory is used to handle the spatial rotations and gives a straightforward and efficient mathematical representation of the module properties in terms of a permutation matrix for the rotation and continuous variables for the topology. This problem, which includes different types of design variables, is solved using a memetic algorithm: a simultaneous analysis and design technique is used for the topology optimization while the module rotation is handled by a genetic algorithm.

The proposed approach is compared with the optimization of periodic modular structures, where the module orientation is a priori fixed, taking advantage to the structural symmetry. An academic truss bridge is studied, where the efficiency of the present technique is clearly demonstrated through the simultaneous optimization of the topology and the module orientation, with a limited computation effort.

References

[1] X. Huang and Y. M. Xie, Optimization design of periodic structures using evolutionary topology optimization, Structural and Multidisciplinary Optimization, 36, 597-606, 2008.