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Integrated Optimization of Macroscopic Topology and Microscopic Configuration of the Graded Functional Cellular Structures

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ABSTRACT

In the topology optimization of the multiscale structure, ensuring connectivity between adjacent microstructures, controlling the design space of microstructures, and reducing calculation amount and improving calculation efficiency are three basic challenging issues currently faced. To address this, this paper presents a data-driven approach for the integrated optimization of macroscopic topology and microscopic configuration of graded functional cellular structures. At the macro level, a topological description function is introduced to realize the topological control of the macro structure. At the micro level, several cutting functions are used to realize the control of the configuration and size of the microstructure. Based on computational homogenization method and numerical integration technology, a problem-independent offline database of microstructure is established at the microscopic scale, where the relationship between the equivalent elastic parameters, relative pseudo-density and design variables of the microstructure is stored. Based on this offline database, the entire topology optimization process is completed only on a macro scale, which greatly reduces the amount of calculation and improves calculation efficiency. Additionally, implicit geometric modeling of full-scale cellular structures can be achieved using the reconstruction technique in this work, ensuring smooth connection between adjacent microstructures. Finally, numerical examples are used to verify the effectiveness of the algorithm and the superiority of gradient cellular structures compared with single-scale structures.

KEYWORDS

Graded cellular structure, integrated optimization, data-driven, computational homogenization, M-VCUT

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