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Minimizing Machinery Vibration Transmission in a Lightweight Building using Topology Optimization

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Abstract

The problem of minimizing the vibration transmission in a lightweight building from a vibrating machine is studied in this paper by topology optimization of a flexible, single-material base plate for the machinery. The design optimization aims to minimize the vibration response of the building transmitted from the machinery via its base plate placed in a given installation room, and the elastic walls and floors of the building. The machine is considered to be relatively stiff (approximately modeled as a rigid body), and is assumed to be subjected to forced, time-harmonic excitation of given amplitude and frequency. The machine is rigidly connected to the base plate via four bolts, and the four corners of a quadratic admissible design domain for the base plate are assumed to be connected to the elastic floor in the installation room by moment-free hinges.

The building is modeled as a modular lightweight building and used for analyses of the forced vibration transmission as well as frequencies and corresponding modes of free vibrations. The entire building is constructed by translation and combination of three basic modular elements, i.e. one floor panel and two different wall panels. The floor and wall panels are considered as interior beam-stiffened double-leaf panels. With a view to reduce the modelling and analysis cost, each panel is homogenized into an equivalent sandwich plate with two isotropic skin layers and an orthotropic core layer.

The design objective is chosen as minimization of the product of the frequency response of the building and the volume of material used for the design of the base plate. The classical SIMP method and a density filter are used in the topological design of the base plate. A maximum constraint is specified for the static displacement of the machine since the optimization of the base plate otherwise attempts to achieve minimum frequency response (zero) of the building by separating the building from the vibration source. This trivial solution is, of course, not useful.

Different excitation frequencies and values of the maximum constraint on the static displacement of the machine are considered, and the design and performance of the optimized machinery base plates are illustrated and discussed via numerical examples.