INSTITUT NATIONAL DES SCIENCES APPLIQUÉES CENTRE VAL DE LOIRE

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Wave propagation in periodic structures with local nonlinearities

Subject: This Ph.D. proposal aims at analyzing the propagation of waves in structures which are 1D periodic, i.e., structures which are composed of identical substructures that are assembled to each other along a straight or circular direction. Those substructures can be of complex 2D or 3D shape, and as such, they are usually modeled via finite elements. Such periodic structures may represent, for instance, an aircraft fuselage, a turbine, or a railway track lying on a foundation of periodic supports. For periodic structures connected to an array of springs or resonant devices (mass-spring systems), it is well known that band gap effects occur. These result from Bragg scattering or local resonance phenomena, and are characterized by frequency bands on which waves do not propagate. Hence, band gap effects constitute an interesting means to passively control the vibration and sound levels of engineering structures. The use of nonlinear devices, instead of linear springs and linear mass-spring systems, seems interesting for improving the band gaps effects. This aims at increasing the bandwidths at which band gaps occur to make them useful for a wider range of engineering applications. The Ph.D. studies will start with the modeling of linear periodic structures. For this purpose, the wave finite element (WFE) method will be investigated. This method is indeed well appropriate for computing the waves which propagate in periodic structures made up of complex substructures. The modeling of periodic structures with local nonlinearities, such as nonlinear springs, will be further undertaken. Especially, the wave properties (wave number, wave speed) for one wave propagating along an infinite periodic structure coupled to an array of weak nonlinearities will be analyzed. Also, the forced response of nonlinear periodic structures, which are of semi-infinite or finite dimensions, will be examined. The related issues mostly concern the consideration of several waves in the modeling of a periodic structure, and the coupling effects between these waves which result from the nonlinear effects. Numerical issues about the computation of the wave-based nonlinear matrix equations, which will be used to model such periodic structures, will be also addressed. An optimization procedure of the design of nonlinear periodic structures will be finally proposed so as to improve the band gap effects in these structures.

Keywords: structural vibration, periodic structures, nonlinearities, wave finite element method.

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Additional information: This subject is part of the research topics developed within the Dynamics Group of the LaMé Laboratory.