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Transformative Wave Attenuation Techniques for 1D Composite Structures with Inerter

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This article introduces a novel technique for mitigating longitudinal elastic waves in one-dimensional (1D) composite structures by utilizing inerter-based vibration absorbers paired with multifrequency resonators (MFRs). The proposed 1D resonant structure features an array of regularly spaced inerter-based absorbers embedded along an isotropic 1D framework. Each absorber is equipped with a system of spring-mass resonators connected at two critical points, significantly enhancing the ability to suppress wave propagation. Through an analytical approach leveraging Finite Element Modeling (FEM) and Bloch's theorem, the study reveals the presence of multiple stopbands, creating wide and tunable frequency ranges where wave transmission is effectively suppressed. The design and modeling of this resonant structure demonstrate that wave attenuation is grounded in well-established mechanical vibration absorption principles. The inerter-based absorbers generate two opposing internal forces that neutralize incoming longitudinal waves within the stopband frequencies. By adjusting key properties such as inerter, stiffness, and mass, these absorbers can be finely tuned to optimize their wave-blocking performance. A detailed parametric study explores how variations in the MFRs' characteristics, including inerter, mass, and stiffness, influence the location and size of the stopbands. The results from FEM simulations align closely with theoretical dispersion curves across various configurations, providing strong validation of the design. This approach, which leverages inerter-based vibration absorbers for efficient wave control, holds significant promise for applications where precise manipulation and attenuation of wave propagation are crucial.

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