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Analysis of Flexural Vibrations and Control of a Periodic Rail-Track System

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Abstract

Vibrations generated from the passage of trains including that from metros often get transmitted to the adjacent structures including buildings. This problem is particularly serious in cities wherein the resulting vibrations can either cause structural issues or can lead to serious discomfort for the occupants. Also, wheel-rail interaction often produces unwanted noise which can affect the inhabitants of the buildings near to these tracks. Understanding the propagation behavior of vibrations in the rail and thereby to the adjacent structures is essential in order to efficiently control them. Thus, the propagation behavior of flexural wave in a typical rail is analyzed in the context of Floquet-Bloch theorem for periodic structures. The ensuing dispersion relations are validated using finite element models. Subsequently, two-degrees-of-freedom resonators are coupled with rail to tune the stop band characteristics. The targeted frequency ranges in the considered pass band are very efficiently controlled using these resonators. Further, the efficacy of this control strategy is assessed using a random Gaussian white noise loading in the time domain and comparing the resulting vibration transmission characteristics from the original rail with that of the rail embedded with the proposed resonators. This study helps to realize the propagation characteristics of flexural waves in rails and the design of passive control mechanisms to reduce the transmission of the resulting vibrations.

Keywords: Periodic rail-track system, Vertical flexural wave, Dispersion relation, Passive control, Two-degree-of-freedom resonator