

Analytical Solution for the Free Vibration of Short-Fiber-Reinforced Rayleigh Beams on an Orthotropic Pasternak Foundation

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ABSTRACT

This study investigates the free vibration behavior of short-fiber-reinforced composite (SFRC) beams resting on an orthotropic Pasternak elastic foundation. The effective mechanical properties of the composite beam are evaluated using the classical mixture rule to capture the microstructural influence of short-fiber reinforcement. SFRC beams have attracted increasing attention in recent years; however, studies addressing their free vibration response, especially in the presence of elastic foundation effects, remain relatively few. Moreover, although the free vibration analysis of SFRC beams on elastic foundations has been studied in detail, the available literature [1] primarily focuses on the isotropic Pasternak foundation model. To the best of the authors' knowledge, the vibration behavior of SFRC beams supported by orthotropic foundations has not yet been addressed. To fill this gap, an orthotropic Pasternak foundation model [2] is incorporated into the free vibration analysis of SFRC beams within the framework of Rayleigh beam theory. The formulation accounts for direction-dependent shear stiffness parameters, enabling a more representative description of foundation–structure interaction when the supporting medium exhibits orthotropic behavior. The equations of motion are derived based on the Rayleigh beam theory, and the problem is solved analytically using the Navier method to obtain the natural frequencies. A parametric study is then performed to examine the effects of the short-fiber volume fraction, the ratio of foundation orthotropy, and rotary inertia on the vibration characteristics. The results indicate that foundation orthotropy has a pronounced influence on the vibration frequencies of SFRC beams, highlighting the importance of accounting for direction-dependent medium properties in the free vibration analysis and design of composite beam systems.

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