

Material Based Damping Innovation using Bio based Composites for Sustainable and Seismic Resilient Communities

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Abstract

The increasing demand for sustainable and earthquake-resilient infrastructure has motivated the development of alternative seismic response control strategies that reduce environmental impact while maintaining structural safety. In this context, bio-based materials derived from natural fibers and bio-polymers have attracted growing attention due to their inherent viscoelastic behavior and potential for energy dissipation. However, most existing studies remain limited to material-level characterization, with little emphasis on their contribution to structural system performance under seismic loading. This study introduces a material-based damping approach by integrating bio-based high-damping materials directly into structural components, enabling seismic energy dissipation without relying on conventional external damping devices. The research focuses on low-rise reinforced concrete frame structures enhanced with bio-based composite materials acting as structural or supplementary elements. The intrinsic damping characteristics of the bio-based materials are represented through equivalent viscoelastic and hysteretic damping models, allowing their contribution to global structural response to be explicitly evaluated. Numerical simulations are performed using response spectrum and nonlinear time-history analyses under selected earthquake ground motions representative of seismic regions. The seismic performance of structures incorporating bio-based materials is compared with that of conventional structures in terms of interstory drift ratio, floor acceleration, hysteretic behavior, and cumulative energy dissipation. A parametric study is also conducted to examine the influence of material damping properties on seismic response. The results demonstrate that the integration of bio-based high-damping materials leads to a noticeable reduction in seismic demand, particularly in peak drift and vibration response, while significantly enhancing energy dissipation capacity. Rather than replacing conventional damping devices, the proposed approach provides an effective supplementary damping mechanism embedded within the structural system. The findings highlight the potential of bio-based materials as a sustainable solution for improving seismic resilience in low-rise buildings and support their application in environmentally responsible earthquake-resistant structural design.

Keywords: Bio-based materials, intrinsic damping, seismic response, sustainable structures, energy dissipation