

A Combined Honeycomb and Solid Viscoelastic Material for Structural Damping Applications

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Summary

The goal of the research described in this paper is to investigate the feasibility of a new combined polymer composite damping system, which consists of a polymer honeycomb material and a viscoelastic solid material. This new combined viscoelastic system, which is intended primarily for energy dissipation and vibration control, serves as an interface layer within lightweight composite panels subjected to in-plane shear. The basic concept and mechanical properties of the combination of polymer honeycomb and solid viscoelastic materials were experimentally investigated under different strain and frequencies inputs. Numerical models in which the effect of temperature and frequency are taken into account were then established. Analytical results given by a simplified numerical model agreed well with experimental results. This study also led to useful information about the optimum design of the combined damping system.

Description of Research

A multi-layer energy-dissipating panel was recently proposed by Aref and Jung (2001) for the retrofit of semi-rigidly connected steel frames. These multi-layer composite panels are characterized by shear interface layers, which are composed of polymer honeycomb material placed between composite laminates consisting of several plies. A characteristic feature of this composite panel system is its ability to provide a significant level of damping due to interface slip at contact surfaces.

The design of composite infill panels as a damping component for seismic applications faces the following challenge. If the interface material is sufficiently stiff, deformations at the interface might not be large enough as to provide a significant level of energy dissipation. On the other hand, materials such as a solid viscoelastic material dissipate a significant amount of energy but at the expense of making the structure too flexible. The new interfacing damping system described in this paper seeks to comply with both of the desired properties (i.e., stiffness and energy dissipation capability) by combining two composite materials. A schematic representation of the idealized force-displacement relationship is shown in Figure 1. Once incorporated into a structure, the enhanced passive damping of this new interface layers modifies key structural design parameters such as structural mass, stiffness, and damping characteristics.

The effectiveness of the combined composite damping material system in increasing the energy dissipated between fiber reinforced polymer (FRP) skin plates is the primary interest of this research. This new layer configuration consists of two different styles of composite materials: a polymer honeycomb material and a solid viscoelastic material. This configuration is intended to increase the level of damping provided. The honeycomb material is expected to enhance the stiffness of the

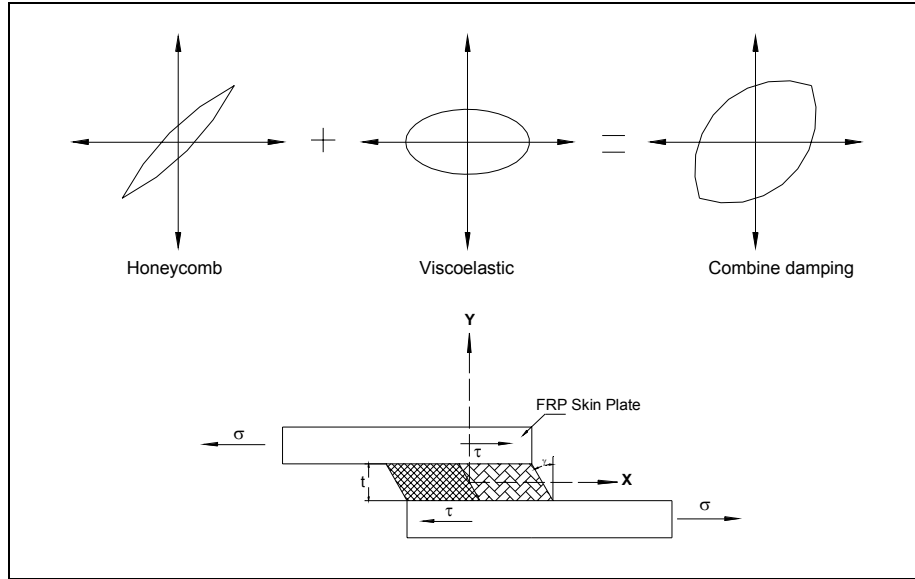


Figure 1. Schematic presentation of the idealized force-displacement relationship

entire structure, whereas the solid viscoelastic material is expected to improve the energy dissipation capability of the multi-layer panel system when subjected to in-plane shear loading. Figure 2 presents experimental force-displacement relationships for two different damping systems. Figure 3 shows the amount of energy dissipated by each of the three systems considered at different frequencies. Both figures show that, except at very low frequencies, the energy dissipation capability of the combined system is significantly better than that of systems consisting of only one of either composite materials (polymer honeycomb or solid viscoelastic).

Finally, the optimal design of the proposed combined polymer composite damping system was investigated. Several cases were considered in order to find the best combination of several relevant factors such as cost and fabrication. Numerous experimental and analytical studies were performed. Based on these results, simplified design procedures were developed to improve the stiffness and the damping characteristics of the energy dissipating material.

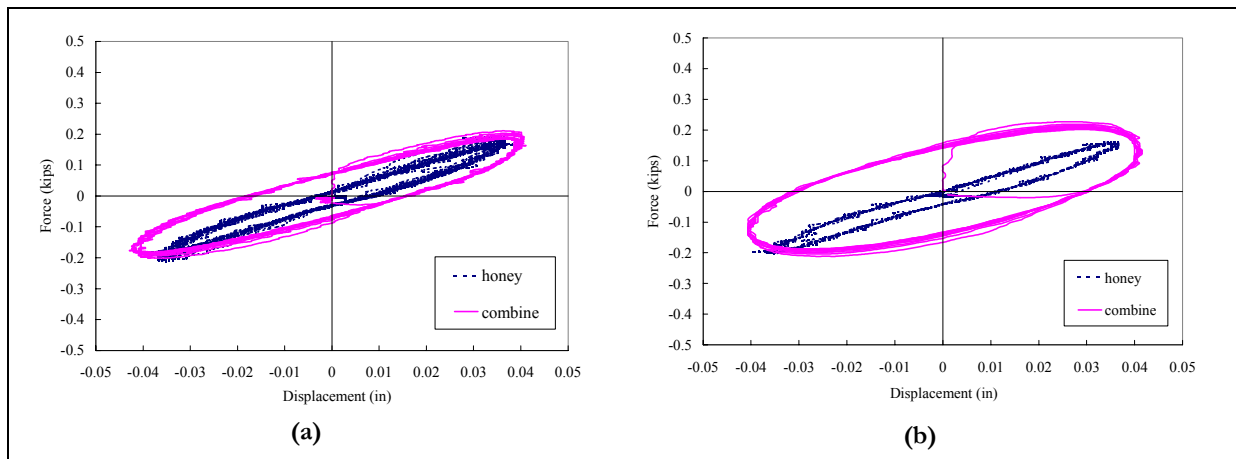


Figure 2. Experimental force-displacement relationships: (a) $f = 1$ Hz; (b) $f = 3$ Hz

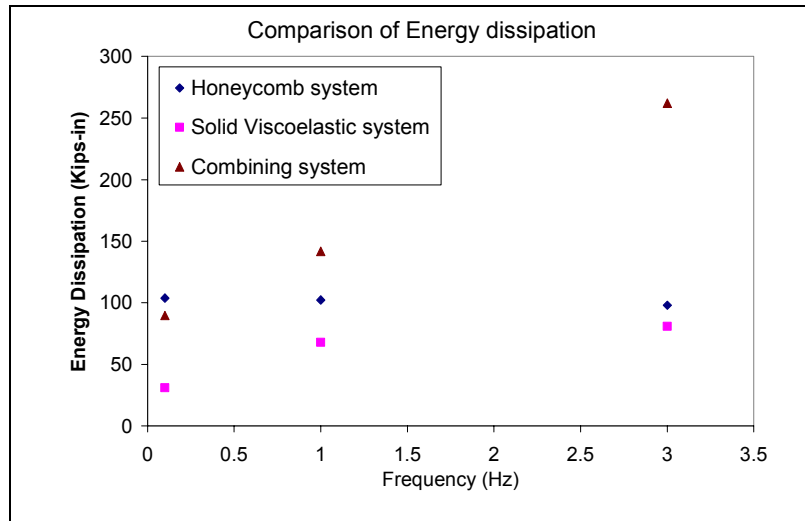


Figure 3. Energy-dissipation-versus-frequency relationship

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References

Aref AJ, Jung WY (2001): Polymer matrix composite infill walls for seismic retrofit. *Proceedings of the 2001 Structures Congress & Exposition*, American Society of Civil Engineers, Reston, VA.