STUDY ON DAMPING PROPERTIES OF BAMBOO SANDWICH STRUCTURES

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Abstract

The aim of the research paper is to study the effects of density of polyurethane foam (PUF) and skin materials. Epoxy and polyester based bamboo on the damping properties of PUF structures were investigated. Three different types of specimens with three foam densities were considered. The effect of the skin type, the density of foam, interface bonding and the operating temperature on the damping behavior of the sandwich structure are studied. The maximum peak damping capacity at 0°C in case of polyester based specimens for a foam density 600 kg/m^3 was achieved. The damping initially increase in temperature range from –20 to 0 °C, attained peak value at 0 ° C, further decrased marginally up to 60 ° C and finally, drastically decreased in the temperature range 60 to 100 °C.

Introduction

High damping capacity and lightweight structures have potential applications in weight-critical aerospace, space and automotive applications. It implies that higher stiffness and lower density materials possess higher natural frequency and hence higher damping capacity [1]. Viscoelastic materials are inserted into structural components to damp vibrations in structures in aerospace satellites, electrical and automobile components. [2,3]. One potential means of obtaining material of higher damping capacity is through sandwich structures [4]. Traditionally sandwich structures have two thin metal faces and rigid foam. Researchers [4-5] have reported successful development of sandwich structures replacing the two thin metal plates with fiber-reinforced plastic.

The damping capacity of a material refers to its ability to convert mechanical vibration energy into thermal energy. Damping is a critically important structural property from the viewpoint of vibration suppression in moving structures. With the advent of sandwich technology it has became possible to modify the damping behavior of the sandwich structures replacing the thin metal plates with non-metallic phases such as FRPs. FRPs may combine the ductility, toughness of the matrix with the high strength and high modulus characteristics of the fibers. Measurement of dynamic modulus in sandwich structures often provides a more flexible and accurate alternative to standard static testing techniques.

Material preparation

Sandwich specimens were fabricated according to the standard specifications. The specimens consist of a bamboo fabric reinforced plastic skins and polyurethane foam core. Table 1 shows the material specifications. The primary chemicals used to produce the PU foam were methylene di-isocynate (MDI) and polyether Polyol (PP).

Table 1 Materials of the specimen

Construction	Material	Specification
Skin	Bamboo fabric	Bamboo
Resin	Epoxy	LY556
Resin	Polyester	Polyester
Foam	PU foam	Density 0.6 - 0.7 gm/cc

The procedure for fabricating sandwich specimens is prepared three steps 1. Foam preparation (MDI + PP liquids) different densities of 0.6, 0.65 and 0.7 gm/cc, 2. Preparation of polyester/ bamboo and epoxy / bamboo skin and 3. Fabricate polyester/bamboo-PUF-polyester/bamboo (PPP), polyester/bamboo-PUF-epoxy/bamboo (PPE) and epoxy/bamboo-PUF-epoxy/bamboo (EPE) using hot press at pressure of 0.5 MPa at 120 °C for 3 hours

The Rheovibron model was used to measure the dynamic mechanical properties, namely, storage modulus (E'), loss modulus (E") and damping capacity at 110 Hz. The temperature of the specimen was varied from -20°C to 100°C both in the heating and cooling cycle at the rate of 10°C/min and the corresponding plots of average values of loss modulus and storage modulus were obtained and tangent of the phase angle (δ) was recorded. The damping capacity is defined by tan (δ).

3. Results & Discussion

The plots of damping capacity obtained for EPE, EPP and PPP sandwich structures with the three foam densities in the temperature range -20°C to 100 °C are shown in Fig 1. The plots of damping capacity in all the three cases, showed the following pattern:

1. Steep increase in damping capacity (-20 to 0°C)
2. Point of inflection at 0°C
3. Marginal decrease (0 to 60°C).
4. Drastic decrease (60-100°C).

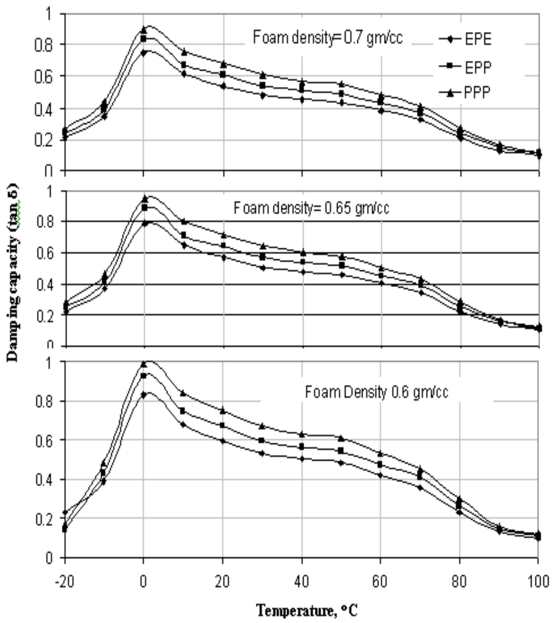

Fig. 1 Damping capacity vs. temperature

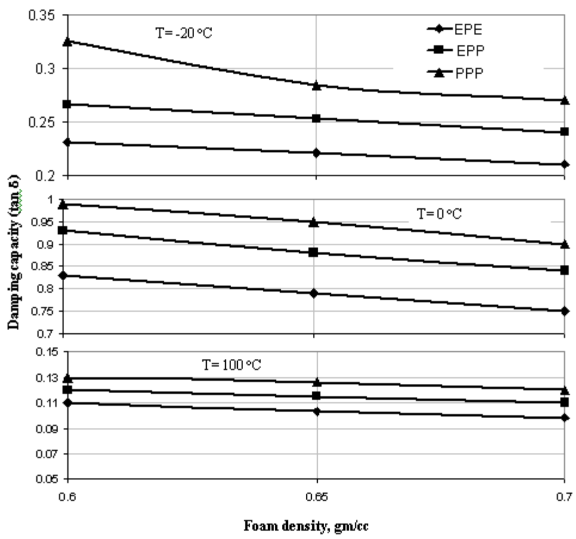

Fig. 2 Damping capacity vs. foam density

The plots of damping capacity for EPE, EPP, and PPP sandwich panels for different foam densities of 0.6, 0.65 and 0.7 gm/cc are shown in Fig 2. It is observed that the damping capacity increases with decrease in foam density for all the three types of specimens and for the entire testing temperature range

Very nominal decrease in damping capacity is observed at –20°C, the variation being 0.04 to 0.06. Significant decrease in damping capacity (0.1 to 0.2) is observed at 0 °C. Again marginal decrease in damping capacity (0.01-0.02) is observed at 100°C. The sandwich structures are composed of three distinct zones; the quasibrittle energy absorbing Viscoelastic PUF core; the elastic outer FRP skins and interface bonding between the skin and the foam. Each zone contributes to the overall damping capacity of the sandwich structure in its own way, irrespective of the operating temperature.

The Viscoelastic PUF absorbs mechanical energy by means of converting the vibration energy into heat energy. The vibration waves induce compression and expansion of the foam cells, which causes continuous movement of gas present in the foam cells. According gas law, in compression, the temperature raises due to the intermolecular friction in air and between the air molecules and adjacent foam walls. Hence, the internal friction among macromolecular segments increases to covert mechanical energy into heat. Meanwhile, the interaction between macromolecules between air and adjacent layer becomes violent. The increment in the internal friction and the interaction gas molecules and the adjacent foam layer increases the mechanical dissipation and hence, enhances the vibration damping.

5. Conclusion

All the three types of sandwich structures showed similar behavior in damping. The behavior of sandwich structures in the three temperature zones, namely, –20 to 0°C, 0 to 60 °C, and 60 to 100°C showed increase, marginal decrease and drastic decrease in damping capacities, respectively. The damping capacity increased with decrease in density of foam. PPP specimens showed superior damping property. Skin material, foam, interface bonding and operating temperature have effect on the damping properties of the sandwich structures.

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