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The Energy-Absorbing Behaviour of Composite Tube-reinforced Foams

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Abstract

This paper investigates the energy-absorbing characteristics of composite tube reinforced PVC foam cores for use in lightweight impact-resistant sandwich structures. Compression tests have been conducted on crosslinked PVC foam cores with densities ranging from 40 to 130 kg/m^3, reinforced with both glass fibre and carbon/glass fibre composite tubes. The energy-absorbing capability of these reinforced foams was evaluated by determining the specific energy absorption of each configuration. The mechanical response of the tube-reinforced foams was also modeled using the finite element method. The validated models shown good agreement with the experimental data, with the model accurately predicting the compressive responses and failure characteristics in the samples. Drop-weight impact tests have also been undertaken in order to investigate their dynamic performance and ability to absorb energy under crash conditions.

It has been shown that embedding the tubes in a foam panel serves to modify the failure process occurring within the composite tubes, greatly enhancing their ability to absorb energy. However, when normalized by the mass of the test sample, the SEA values of the hybrid tube reinforced foams were found to be largely insensitive to variations in foam density, suggesting that reinforced low density foams, where the associated crushing forces are low, are best suited to energy-absorbing applications. In contrast, the SEA data for the unidirectional glass tube reinforced systems steadily increase with increasing foam density. The dynamic values of SEA for the tube-reinforced systems were lower than those measured at quasi-static rates, suggesting a rate-sensitivity in the fracture processes within the composite. Finally, it is shown that the energy-absorbing capability of tube-based foams is higher than many comparable core systems, where their potential for use under conditions of extreme crushing are highlighted.

Keywords: Composite tube, Reinforced PVC foam, Energy absorption, Finite element method