Dynamic Compression Characterization of Multilayered Composite Materials Using SHPB

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Engineered wood products and bio-based layered materials are widely used due to their favorable strength-to-weight ratio, energy absorption capabilities, and potential for sustainable material design. In many engineering applications, including impact loading, crash scenarios, and high-rate material processing, these materials are subjected to dynamic loading conditions. However, material models are often based on quasistatic data, which do not adequately capture their behaviour at high strain rates. This limitation is particularly critical for anisotropic multilayered composites, where strain-rate sensitivity, interlayer interactions, and wave propagation effects influence both the mechanical response and the governing failure mechanisms. Reliable experimental methods are therefore required to improve understanding and support predictive modelling.

The Split Hopkinson Pressure Bar (SHPB) technique is a well-established method for investigating material behaviour at strain rates ranging from approximately 10^2 to 10^4 s^{-1} [1]. The method is based on one-dimensional elastic wave propagation in bars, where incident, reflected, and transmitted strain signals are used to determine stress-strain response, strain rate, and energy absorption of the tested specimen (see Fig. 1).

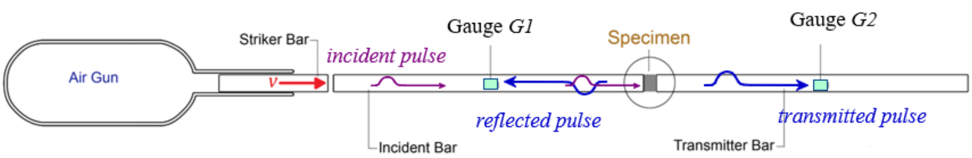

Figure 1. Principal sketch of split Hopkinson pressure bar apparatus.

In this study, compression experiments were performed on selected multilayered composite materials, including carbon-epoxy laminates and Norway spruce. A wide range of strain rates was covered by combining quasi-static testing using an MTS system with high strain-rate experiments using SHPB. Mechanical response parameters, including stress, strain, boundary forces, stiffness, and energy dissipation, were evaluated. The influence of strain rate and material orientation was examined, and differences in deformation and energy absorption between polymer-based and bio-based layered materials were observed.

The results highlight the importance of strain-rate effects in composites under compression and the need for further experimental work to support reliable modelling and engineering design.

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