

ABSTRAK

Material komposit berbasis serat alami memiliki potensi yang besar untuk dikembangkan sebagai material alternatif rompi antipeluru karena memiliki massa yang ringan, mudah diproses, serta memiliki sifat mekanik yang baik. Penelitian ini bertujuan untuk menganalisis pengaruh variasi jumlah serat horizontal dan dimensi kepangan serat bambu pada komposit *hybrid laminate* berbasis serat bambu dan *x-ray film* terhadap kekuatan bending dan ketangguhan impak. Pembuatan komposit dilakukan menggunakan metode *vacuum infusion* dengan variasi jumlah serat horizontal sebanyak 4, 6, dan 7 serat serta dimensi kepangan serat 2 mm, 4 mm, dan 6 mm. Jumlah lapisan *x-ray film* ditetapkan sebanyak enam lapis sebagai material penguat. Pengujian mekanik meliputi uji bending mengacu pada standar ASTM D7264 dan uji impak Charpy mengacu pada ASTM D256. Data hasil pengujian dianalisis menggunakan metode ANOVA dua arah untuk mengetahui pengaruh masing-masing variabel serta interaksinya. Hasil penelitian menunjukkan bahwa dimensi kepangan serat berpengaruh signifikan terhadap kekuatan bending dan ketangguhan impak ($p\text{-value} = 0,000$). Jumlah serat horizontal tidak berpengaruh signifikan terhadap kekuatan bending ($p\text{-value} = 0,195$), namun berpengaruh signifikan terhadap ketangguhan impak ($p\text{-value} = 0,023$). Interaksi antara kedua variabel juga berpengaruh signifikan terhadap kekuatan bending ($p\text{-value} = 0,029$) dan ketangguhan impak ($p\text{-value} = 0,024$). Nilai kekuatan bending tertinggi sebesar 108,759 MPa diperoleh pada variasi dimensi kepangan 4 mm dengan jumlah serat horizontal 7, sedangkan ketangguhan impak tertinggi sebesar 110,41 kJ/m² diperoleh pada variasi dimensi kepangan 4 mm dengan jumlah serat horizontal 4. Hasil penelitian menunjukkan bahwa kombinasi dimensi kepangan dan jumlah serat horizontal yang tepat mampu meningkatkan performa mekanik komposit *hybrid laminate*, sehingga berpotensi dikembangkan sebagai material alternatif rompi antipeluru.

Kata kunci: komposit *hybrid laminate*, serat bambu, *x-ray film*, *vacuum infusion*, kekuatan bending, ketangguhan impak, ANOVA dua arah.

ABSTRACT

Natural fiber-reinforced composites have significant potential to be developed as alternative materials for bulletproof vests due to their lightweight characteristics, ease of fabrication, and favorable mechanical properties. This study aimed to investigate the effect of variations in the number of horizontal bamboo fibers and the dimensions of braided bamboo fibers in bamboo fiber/*x-ray film* hybrid laminate composites on flexural strength and impact toughness. The composites were fabricated using the vacuum infusion method with variations in the number of horizontal fibers of 4, 6, and 7, and braided fiber dimensions of 2 mm, 4 mm, and 6 mm. The number of *x-ray film* layers was fixed at six as the reinforcing material. Mechanical characterization was conducted through three-point bending tests based on ASTM D7264 and Charpy impact tests based on ASTM D256. The experimental data were analyzed using two-way Analysis of Variance (ANOVA) to determine the effects of each variable and their interaction. The results indicated that the braided fiber dimension had a significant effect on both flexural strength and impact toughness (p -value = 0.000). The number of horizontal fibers had no significant effect on flexural strength (p -value = 0.195), but significantly affected impact toughness (p -value = 0.023). Furthermore, the interaction between braided fiber dimension and the number of horizontal fibers significantly influenced flexural strength (p -value = 0.029) and impact toughness (p -value = 0.024). The highest flexural strength of 108.759 MPa was achieved by the composite with a 4 mm braided fiber dimension and 7 horizontal fibers, while the highest impact toughness of 110.41 kJ/m² was obtained with a 4 mm braided fiber dimension and 4 horizontal fibers. These findings demonstrate that an appropriate combination of braided fiber dimensions and horizontal fiber arrangement can significantly enhance the mechanical performance of hybrid laminate composites, indicating their potential application as alternative materials for bulletproof vests.

Keywords: *hybrid laminate composite, bamboo fiber, x-ray film, vacuum infusion, flexural strength, impact toughness, two-way ANOVA.*