Biobased Composite-Metal Hybrids
On Vibrational Damping and Impact Resistance of FLAx REinforced Aluminum (FLARE)

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Publication date
2025

Document Version
Final published version

Citation (APA)
Mosleh, Y., Alcaraz, M., & Alderliesten, R. C. (2025). *Biobased Composite-Metal Hybrids: On Vibrational Damping and Impact Resistance of FLAx REinforced Aluminum (FLARE)*. Abstract from 6th International Conference on Hybrid Materials and Structures, Noordwijk, Netherlands.
https://dgm.de/hybrid/2025/program/scientific-program?tab=2025-04-10&event_item=7bf56a17-c9f6-4943-afae-49e7cce3619d

Biobased Composite-Metal Hybrids: On Vibrational Damping and Impact Resistance of FLAx REinforced Aluminum (FLARE)

6th International Conference on Hybrid Materials and Structures: Hybrid 2025
1:00 PM - 1:20 PM 04/10/2025 (Thursday)
Ariane Room
Session
B-3: Session 3

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Fiber metal laminates (FMLs) or metal-composite hybrid materials synergize the advantages of metals and composites, in particular, they combine the impact resistance of metals and the excellent fatigue and corrosion resistance of fiber-reinforced polymers. FMLs have been mainly used in aerospace applications with synthetic fibers as in GLARE. However, with the rising concerns about climate change, and the issues of recycling glass fiber composites, a new generation of FMLs with a reduced carbon footprint could be a promising course of action. This can be achieved by using bio-based fiber-reinforced composite layers, particularly flax instead of glass fiber composites, rendering FLAx REinforced Aluminum (FLARE), a partially biobased FML with lower embodied energy, in which aluminum layers can be recycled by incineration with energy recuperation of the flax composite. Contrary to conventional FMLs, FLARE can entail some unique benefits of natural fibers such as vibrational damping, thanks to the intricate flax fiber microstructure. Flax fibres demonstrate promising specific mechanical properties compared to glass fibres, particularly regarding tensile stiffness and bending stiffness and strength. This means that flax fibres can outperform glass fibres in stiffness-based designs, particularly in bending mode. This includes applications in the transportation and construction sectors as well as secondary structures for civil aircraft.

This study pioneers the examination of FLARE, focusing specifically on its key distinguishing features, namely its vibration damping and impact resistance capabilities which were not previously scrutinized. Dynamic mechanical analysis and vibration beam tests demonstrate that the metallic layer predominantly influences the damping behavior of FLARE. The loss factor notably decreases with aluminum addition approximated via an inverse mixture rule.

The low-velocity impact resistance of FLARE was compared with that of E-GLARE, with a focus on assessing the influence of MVF and fiber type. Impact tests highlight the role of aluminum layers in toughening and energy absorption and the composite strength as a critical factor in impact resistance. FLARE exhibits improved specific energy absorption compared to monolithic flax fiber composites, though 25% reduced energy absorption compared to E-GLARE counterpart. A quasi-static analytical model provides initial impact response estimations, validated by experimental data.

The study underscores the potential of FLARE to enhance the use of bio-based materials in structural applications, offering good mechanical properties thanks to FML concept, and improving the moisture sensitivity of bio-composites with metal acting as a protective layer. Combining flax fiber composites with metal results in a material with specific stiffness comparable to E-GLARE and superior to GFRP. Thus, for applications relying on stiffness-based designs, FLARE emerges as a more environmentally friendly alternative to both E-GLARE and GFRP, addressing recycling challenges effectively.

Finally, this study presents a first overview of the properties of FLARE and verifies the validity of the predictive tools developed for conventional FMLs which help in the design phase to optimize the structure according to specific requirements.