Influence of temperature in the static and dynamic behaviour of sustainable Flax/Agglomerated cork sandwich beam

Gabriel Sánchez-Escudero[1a*], Enrique Barbero[1b], Sonia Sánchez-Sáez[1c]

Department of Continuum Mechanics and Structural Analysis, Universidad Carlos III de Madrid, Av. de la Universidad 30, 28911 Leganés, Madrid, Spain

[a]Gabsanch@pa.uc3m.es, [b]ebarbero@ing.uc3m.es, [c]ssanchez@ing.uc3m.es

Keywords: Sandwich structures, strain rate, Flax, Agglomerated cork, Low temperature.

Abstract

Sandwich composite structures are widely used in lightweight applications and are subjected during service to a wide range of strain rate. The mechanical properties of many materials are affected by the strain rate. Therefore, it is essential to characterize their behaviour across different strain rates. In addition to applied mechanical loads, temperature critically affects the structural response of sandwich structures. Temperature variations modify the stiffness and strength of the constituents, while thermal mismatch generates internal stresses that promote damage.

In response to increasing environmental constraints, sustainable alternatives to conventional composite systems have gained interest. Bio-based materials offer promising solutions; however, their behaviour under different loading regimes and service temperatures, particularly at sub-zero conditions, remains insufficiently understood.

In this study, sandwich beams with flax fibre face sheets and an agglomerated cork core are experimentally investigated. Agglomerated cork offers a bio-based solution with reduced environmental impact. Flax fibre face sheets provide a sustainable alternative to synthetic fibres, combining low density with favourable specific mechanical properties. The mechanical response of the sustainable sandwich was evaluated and compared with a conventional glass/PVC foam system.

Dynamic bending tests were performed using a drop-weight tower, covering average strain rates of 0.88–2.58 s^{-1}, while static bending tests were conducted under displacement control (1.36×10^{-4} s^{-1}), both using a three-point bending configuration. The experimental campaign was conducted at two temperatures: 23 °C and −40 °C. The structural response was characterized in terms of bending stiffness and peak load, together with an assessment of damage. These tests provide a reference to compare the response under static and dynamic regimes, as well as to evaluate the temperature effects on sustainable sandwich beams.

Funding sources

Grant PID2021-12717OB-100 funded by MICIU/AEI/ 10.13039/501100011033 and, as appropriate, by “ERDF A way of making Europe”, by “ERDF/EU”, by the “European Union” or by the “European Union Next Generation EU/PRTR”.

References

[1] M. Ptak, P. Kaczynski, F. A. O. Fernandes, and R. J. A. de Sousa, “Assessing impact velocity and temperature effects on crashworthiness properties of cork material,” *Int. J. Impact Eng.*, vol. 106, pp. 238–248, Aug. 2017, doi: 10.1016/J.IJIMPENG.2017.04.014.

[2] E. Raponi, C. Sergi, S. Boria, J. Tirillò, F. Sarasini, and A. Calzolari, “Temperature effect on impact response of flax/epoxy laminates: Analytical, numerical and experimental results,” *Compos. Struct.*, vol. 274, p. 114316, Oct. 2021, doi: 10.1016/J.COMPSTRUCT.2021.114316.

[3] I. Colamartino, E. Pinato, M. Cavasin, M. Tagliabue, M. Anghileri, and M. Boniardi, “Static, dynamic and impact properties of a high-performance flax-fiber composite,” *Results in Materials*, vol. 20, p. 100493, Dec. 2023, doi: 10.1016/J.RINMA.2023.100493.

[4] F. Sarasini *et al.*, “Static and dynamic characterization of agglomerated cork and related sandwich structures,” *Compos. Struct.*, vol. 212, pp. 439–451, Mar. 2019, doi: 10.1016/J.COMPSTRUCT.2019.01.054.

[5] S. V. Joshi, L. T. Drzal, A. K. Mohanty, and S. Arora, “Are natural fiber composites environmentally superior to glass fiber reinforced composites?,” *Compos. Part A Appl. Sci. Manuf.*, vol. 35, no. 3, pp. 371–376, Mar. 2004, doi: 10.1016/J.COMPOSITESA.2003.09.016.

[6] P. R. Oliveira, M. May, T. H. Panzera, and S. Hiermaier, “Bio-based/green sandwich structures: A review,” *Thin-Walled Structures*, vol. 177, p. 109426, Aug. 2022, doi: 10.1016/J.TWS.2022.109426.