

Verification of numerical homogenization for corrugated boards through experimental tests and simulations

Damian Mrówczyński^{1,*}, Tomasz Gajewski², Jakub K. Grabski³ and Tomasz Garbowski⁴

¹Doctoral School, Poznan University of Life Sciences, Poznań, Poland
e-mail: damian.mrowczynski@up.poznan.pl

²Institute of Structural Analysis, Poznan University of Technology, Poznań, Poland
e-mail: tomasz.gajewski@put.poznan.pl

³Institute of Applied Mechanics, Poznan University of Technology, Poznań, Poland
e-mail: jakub.grabski@put.poznan.pl

⁴Department of Biosystems Engineering, Poznan University of Life Sciences, Poznań, Poland
e-mail: tomasz.garbowski@up.poznan.pl

KEYWORDS: *Numerical Homogenization, Corrugated Board, Finite Element Method.*

ABSTRACT

The study investigates the effectiveness of numerical homogenization [1,2] on corrugated boards, validated through Edge Crush Test (ECT), Bending Stiffness (BNT) in both Machine Direction (MD) and Cross Direction (CD), Shear Stiffness Test (SST), and Torsional Stiffness Test (TST) [3]. Employing the finite element method (FEM) for simulations [4], this technique aims to simplify complex structures into simplified models while preserving essential physical and mechanical properties, crucial for the efficient design and analysis of packaging materials. By comparing the behaviors of a detailed structural model of the corrugated board sample and its homogenized version, the study seeks to confirm the homogenization method's ability to accurately predict the material's performance under various stress conditions. The chosen experimental tests evaluate the material's compressive, bending, shear, and torsional strengths, offering a comprehensive assessment of the board's mechanical characteristics. Demonstrating a strong correlation between the responses of both the detailed and homogenized models in these tests, using FEM, would prove the homogenization technique's reliability in estimating equivalent material parameters. This validation emphasizes the significance of numerical homogenization as a powerful tool for engineers and designers, facilitating precise prediction of corrugated board behavior, optimizing material use, and enhancing the packaging design process.

REFERENCES

- [1] T. Garbowski, T. Gajewski, Determination of transverse shear stiffness of sandwich panels with a corrugated core by numerical homogenization, *Materials*, 14(8), 1976, 2021
- [2] T. Garbowski, A. Knitter-Piątkowska, D. Mrówczyński, Numerical homogenization of multi-layered corrugated cardboard with creasing or perforation, *Materials*, 14(14), 3786, 2021
- [3] T. Garbowski, J. Pozorska, Z. Pozorski, Mechanical Characterization of Corrugated Board: Sensitivity Analysis in Design of Experiments. *Preprints*, 2024030665, 2024
- [4] O.C. Zienkiewicz and R.L. Taylor, *The Finite Element Method: Its Basis and Fundamentals*, Butterworth-Heinemann; 7th Revised ed., 2013