Maxime LEGAY
Ph.D. thesis (2023-2026)
LGP2 (D. Beneventi;
I. Desloges, J. Viguié)

Printing stiffeners on the surface of folding or corrugated boards: a bio-inspired approach to lighten packaging and optimize resource consumption

Impression de renforts à la surface d'emballages cartons: une approche bio-inspirée pour alléger les emballages et optimiser la consommation des ressources.

MatBio
FunPrint

Context / Objectives

Paper industry consumption
- 15-25 m^3 of water / ton of paper
- 2.9 kWh / ton of paper
- 2-3 ton of wood / ton of paper

Two approaches to reduce the use of resources :
1. Lighten packaging
2. Increase the use of recycled pulps in packaging
→ **But how to keep good mechanical performances ?**

3D printing polymer ribs on cardboard packaging boxes

Ribbed structures = high bending stiffness to weight ratio → Printing polymer ribs on cardboard is a promising idea to increase packaging strength adding a reduced weight

- **Finding a suitable deposit material** :
    - → 3D printability
    - → Environmental impact
    - → Mechanical performances
- **Characterizing** the behavior of printed cardboard
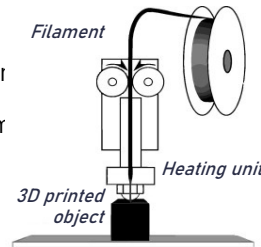- **Optimizing** the geometries of the ribs patterns to maximize the strength to weight ratio
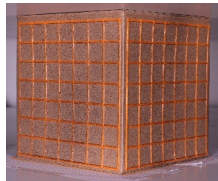
Methods

3D Printing
- **PLA** used as a demonstrator printed by Fused Deposition Modelling = 3D printing from a solid filament
- Ongoing work on **cellulosic paste** cold extrusion

Filament
Heating unit
3D printed object

Mechanical characterizations
Comparison of printed and unprinted cardboard by :
→ **4 points bending** of plates
→ **Compression tests** of boxes

Monitoring the boxes' deformation
→ **Digital Image Correlation (DIC)** to measure the displacement fields of the boxes' surfaces during compression tests
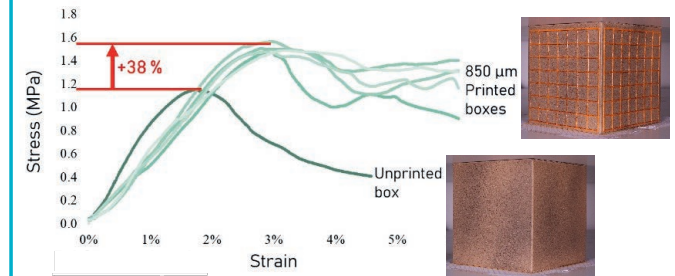
Cameras

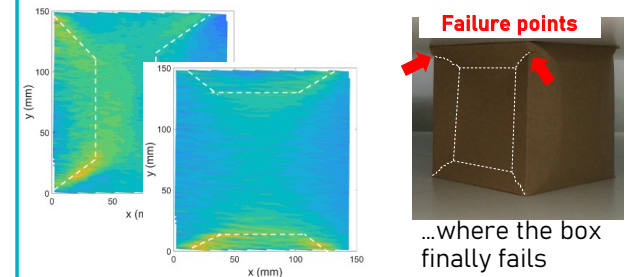w(mm)

y (mm)

x (mm)
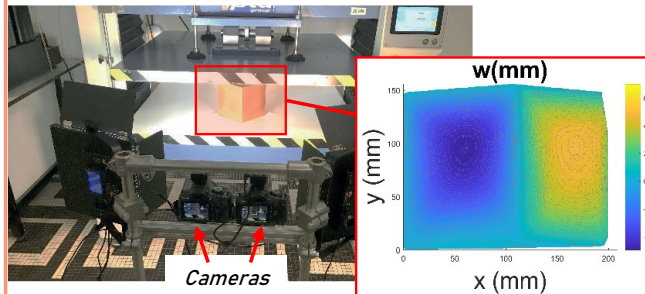
Results

Improvement of the mechanical performances
By printing 850µm thick PLA grids :
→ **Bending stiffness x2** in CD & **x 1.5** in MD for + 50w%
→ **Compression strength +40%** for +20w%

+38 %

850 µm Printed boxes

Unprinted box

Deformation maps of the panels before the rupture highligth some critical zones...

Failure points

...where the box finally fails

→ **Predictive information to improve ribs patterns**