Investigating Mechanical Properties of a 3D-Printed Biomimetic Structure through Three-Point Bending Test.

Abstract

In this study, the bending behavior of a 3D-printed bamboo-inspired biomimetic sandwich structure is investigated experimentally. The structure comprises top and bottom face sheets separated by a periodic cellular core inspired by the cellular structure of bamboo, fabricated using Fused Deposition Modeling (FDM) with PLA+ filament. All specimens were printed under identical processing conditions to isolate the influence of core architecture on mechanical response.

Three-point bending tests were conducted under displacement-controlled loading to evaluate flexural behavior, deformation mechanisms, and failure modes. The biomimetic structure exhibited progressive deformation and delayed failure. These observations indicate effective stress redistribution enabled by the internal cellular design.

The results demonstrate that bio-inspired core architectures can significantly influence bending response and failure behavior in additively manufactured sandwich structures. Future work will extend this experimental framework by integrating data-driven and machine learning-based optimization to correlate geometric parameters with mechanical performance, predictive design of lightweight sandwich structures.

The design consists of:

- A top and bottom face sheet
- A periodic core
- Uniform cell spacing along the beam length

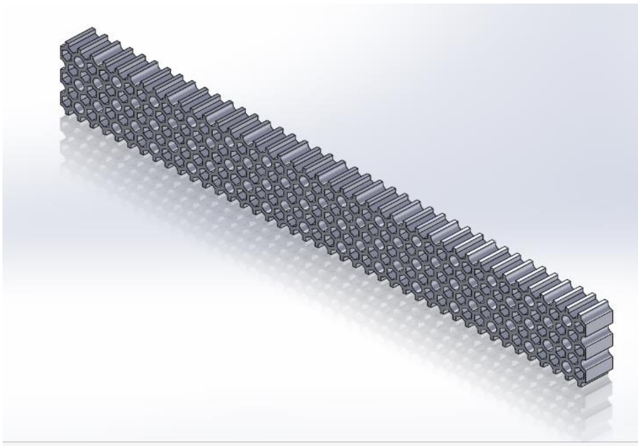
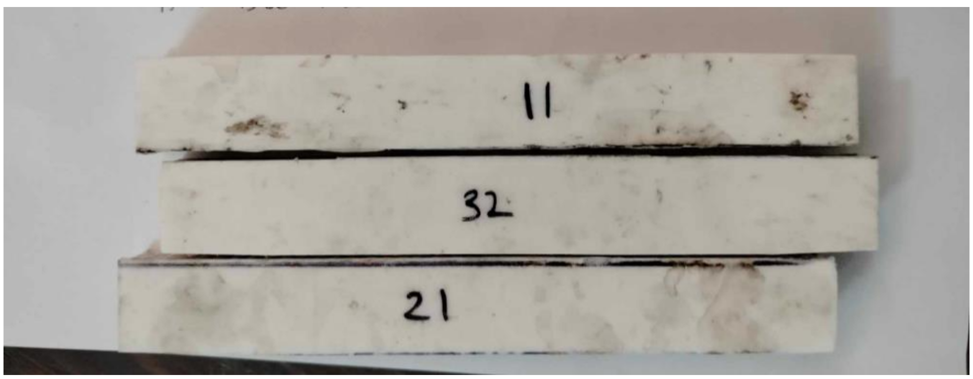


Figure 1. CAD model of the bamboo-inspired biomimetic core structure

(a)



(b)

Figure 2. a) bamboo-inspired biomimetic sandwich structure b) test specimen

All specimens were fabricated using Fused Deposition Modeling (FDM) with PLA+ filament to ensure repeatable printing quality and minimize material variability. Printing parameters such as layer height, infill strategy, and extrusion temperature were kept constant across all samples to isolate the effect of geometry on mechanical response.

Figure 3. Three-point bending test setup for the biomimetic sandwich specimen

Mechanical characterization was performed using a three-point bending configuration on a universal testing machine. Each specimen was placed on two cylindrical supports with a fixed span length, while load was applied at the mid-span through a loading nose.

After testing, the specimen showed noticeable mid-span bending with localized damage in the cellular core. The gradual deformation and delayed failure indicate effective load redistribution provided by the biomimetic architecture.

Figure 4. Post-test deformation and failure behavior of the biomimetic sandwich specimen after three-point bending.

Status: Ongoing research; data-driven and machine learning based optimization planned as future work.