

# The Impact of Elementary Cell Topology on the Bending Tests of 3D Printed Sandwich Beams

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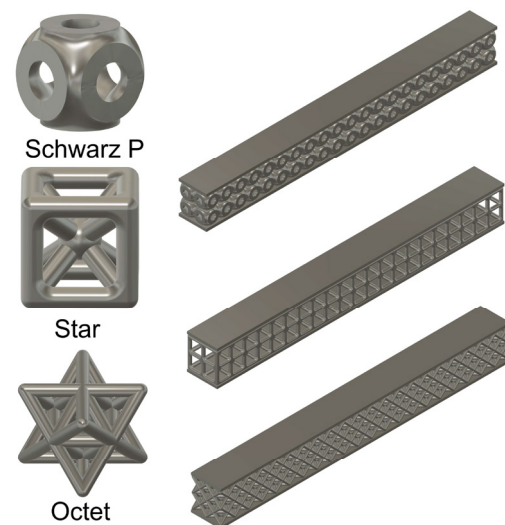
## Summary:

This study investigates the influence of elementary cell topology on the bending behaviour of the 3D printed sandwich beams. Three distinct designs for the cell topologies (Schwarz P, Star and Octet) were fabricated using UV-curable resin and tested under three-point bending conditions. The results indicated that the use of the cell topology Schwarz P gave the highest force resistance and bending stiffness, while the Star design provided a balanced compromise between strength and deformation. In contrast, the Octet-based beam exhibited gradual failure, suggesting its potential for the vibration energy harvesting in micro- and meso-scale.

**Keywords:** 3D printing, sandwich beam, cell topology, bending tests, UV-vat-photopolymerization

## Background, Motivation and Objective

Advances in 3D printing have enabled the production of complex structures that can yield lightweight yet mechanically robust components. Previous studies have highlighted the benefits of using unconventional geometries to optimize properties such as stiffness, strength to weight ratio, vibration damping, as well as energy absorption [1-2]. Although mechanical properties of cell topologies has been explored, there are no results reported for the vat photopolymerization (known commonly as stereolithography, SLA or Digital Light processing, DLP), It is especially demanded, as this technique can downsize the structures to tens micrometers comparing to the Filament Deposition Modelling (FDM) techniques reported in such case [3]. The primary objective of this work was to analyse how three distinct elementary cell designs affect the bending performance of 3D printed structures using UV-curable resins as a building material. By comparing the selected cell topologies (Fig. 1), the research aimed to determine which design offers optimal balance between high load-bearing capacity and ductility. Such comparative analysis was expected to provide valuable insights for designing components where mechanical integrity and controlled deformation are essential, for example in energy harvesting systems.



*Fig. 1. A schematic illustrations of the cell topologies (left) and their use for filling the sandwiched beams (right)- a screen views from Autodesk Fusion (Autodesk, US).*

## Description of the Methodology

Based on [1-2], there were three cell topologies selected: Schwarz P, Star and Octet, due to their superior mechanical properties regarding strength, load capacity, deflection under bending loads and stiffness. To isolate the influence of elementary cell topology on bending performance, a controlled comparative experiment was designed. All specimens were fabricated using the same 3D printer ASIGA MAX X35 (ASIGA, AU),

with the identical photopolymer resin DentaStudy (ASIGA, AU) and printing parameters. Each printed sample had the same external dimensions ( $63,2 \times 6,3 \times 6,6 \text{ mm}^3$ ) and internal cell count ( $21 \times 2 \times 2$ ). This methodological consistency means that any differences in mechanical behavior can be attributed solely to the cell geometry itself. Seven identical samples of each topology were produced and subjected to a standard three-point bending test, using the Chatillon CS2-1100 force tester (AMETEK, US), under identical conditions (span length, support placement, and loading rate held constant). Force-deflection curves were recorded for all tests, and the bending stiffness, strength (peak load) and failure mode were evaluated for each design.

## Results

The bending tests revealed distinct mechanical behaviours for each elementary cell topology. The Schwarz P-based sandwich beam demonstrated the highest average bending force (approximately 63 N) and maximum displacement (about 8,35 mm), with a bending stiffness near 19,58 N/m (Fig. 2). These results confirmed that the continuous minimal surface design of the Schwarz P topology provided superior load-bearing capability and resistance to bending deformation. In contrast, the Star topology-based beam delivered intermediate performance, with an average bending force around 41 N and maximum displacement close to 7 mm, accompanied by a stiffness of approximately 15,64 N/m (Fig. 2). Although not the strongest among the tested geometries, the Star-based beam offered a balanced compromise between strength and flexibility, suggesting its potential suitability in applications requiring moderate deformation. The Octet-based beam exhibited the lowest average bending force (approximately 17 N) and the smallest stiffness (roughly 11,58 N/m) (Fig. 2).

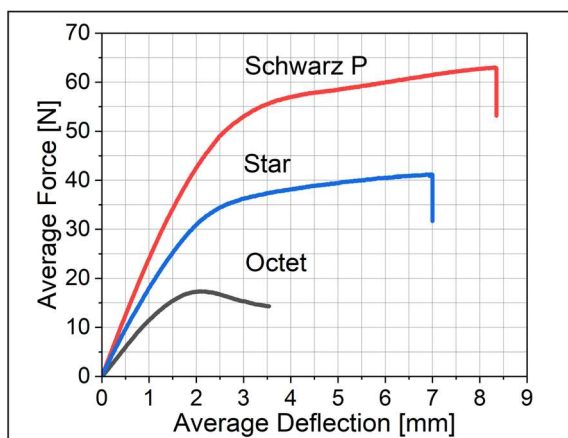


Fig. 2. Graphs of the averaged force values as a function of the averaged deflection values for sandwich structures with the following elementary cell geometries: Schwarz P, Star and Octet.

Notably, the Octet samples displayed a gradual failure mechanism- characterized by progressive cell crushing rather than abrupt fracture. This implied enhanced energy absorption capabilities.

## Conclusions

The experimental investigation confirmed that the topology of the elementary cells in 3D printed sandwich beams significantly impacted their bending behaviour. The obtained distinct responses suggested that design optimization should consider trade-offs beyond mere strength. Future research should explore additional cell geometries, a wider range of material systems, and advanced post-processing techniques to further optimize the mechanical performance of 3D printed structures. Such studies will contribute to the development of tailored components with specific performance characteristics, expanding the application potential of advanced additive manufacturing techniques and may be particularly effective in energy harvesting applications, where controlled deformation and energy dissipation are advantageous.

## References

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## Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101007429. Project co-financed by the Polish Ministry of Education and Science under the program called International Co-financed Projects.



Co-funded by  
the European Union