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Design and Mechanical Evaluation of SLA-Fabricated Gyroid TPMS Sandwich Structures Under Three-Point Bending

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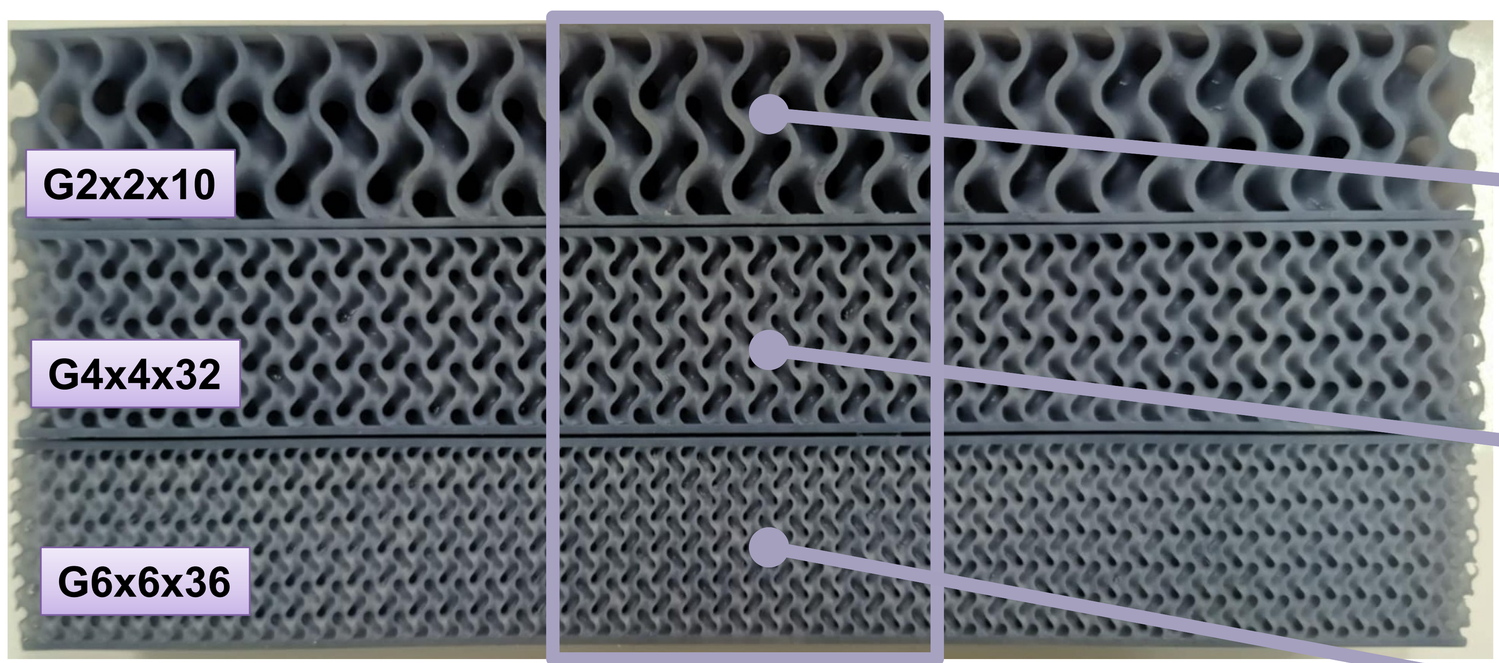
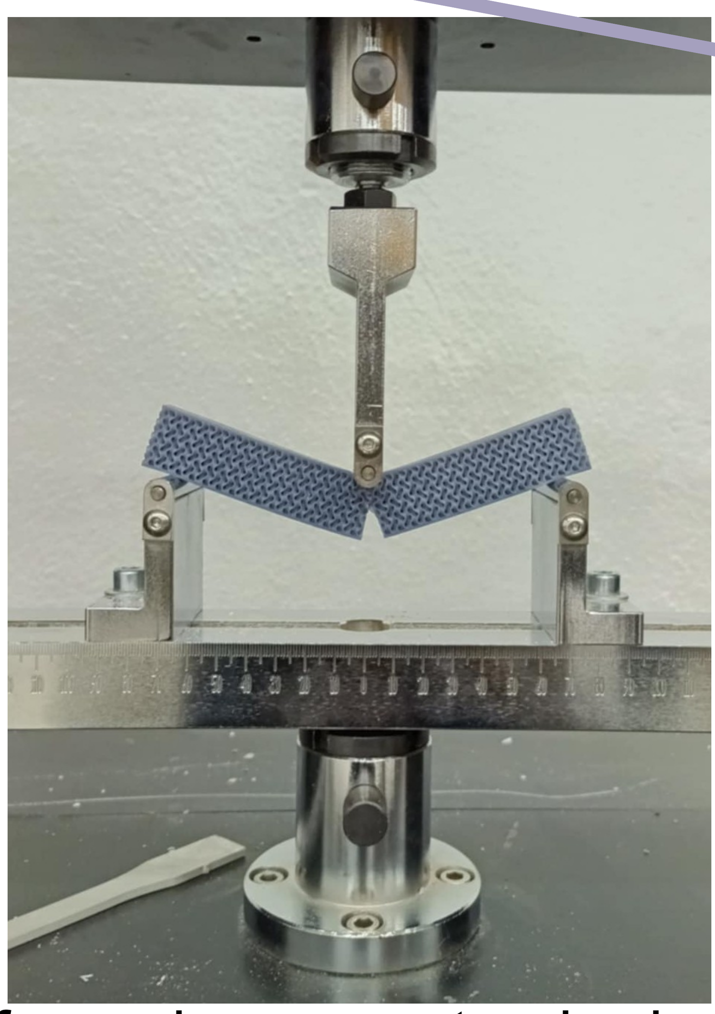
INTRODUCTION & AIM

Gyroid triply periodic minimal surface (TPMS) structures are promising candidates for next-generation lightweight sandwich cores due to their continuous geometry, high stiffness-to-weight ratio, and tunable mechanical response. However, their flexural behaviour is strongly governed by geometric parameters such as unit cell resolution and wall thickness. This study aims to evaluate the mechanical performance of SLA-fabricated gyroid TPMS sandwich beams under three-point bending, focusing on how variations in unit cell size and wall thickness affect stiffness, load transfer, and failure mechanisms.

METHOD





Gyroid TPMS cores with 70% porosity were designed in nTop at three resolutions—2×2×10, 4×4×32, and 6×6×36 unit cells—resulting in decreasing unit cell sizes and wall thicknesses. Each core was integrated between two 1-mm-thick solid faces to form sandwich beams measuring 20 × 20 × 160 mm. Specimens were fabricated using SLA 3D printing with a photosensitive polymer resin, followed by cleaning and post-curing.

Three-point bending tests were performed on a standard fixture according to ASTM C393 to measure flexural response, including core shear modulus and facing bending stiffness. Pre- and post-test micro–Computed Tomography (mCT) scans were conducted to evaluate internal quality, detect defects, and assess damage progression.

CONCLUSION

The flexural performance of gyroid TPMS sandwich beams is strongly governed by unit cell resolution and wall thickness. While structures with thicker walls carry higher loads, the higher-resolution lattices—with more, smaller cells—exhibited delayed failure and a more gradual damage progression, as confirmed by CT imaging. The results highlight a design trade-off between strength and stability, emphasizing the need to balance wall thickness and cell resolution to optimise TPMS sandwich cores for lightweight structural applications.

REFERENCES

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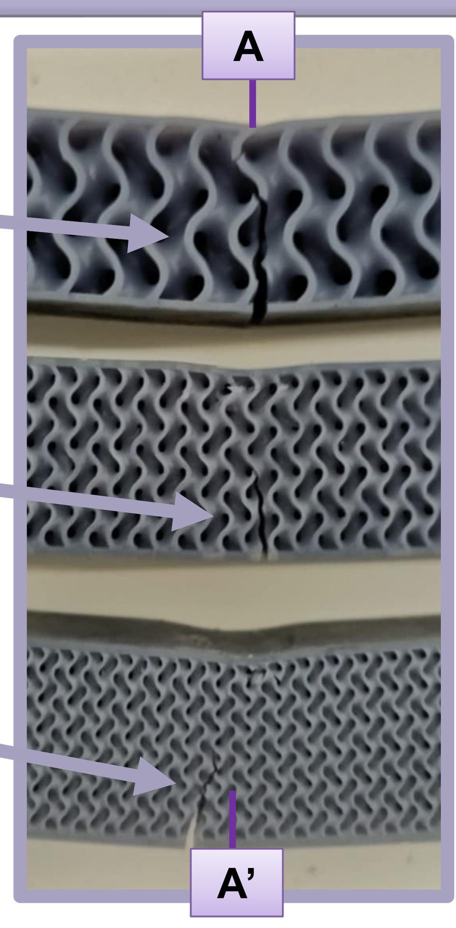
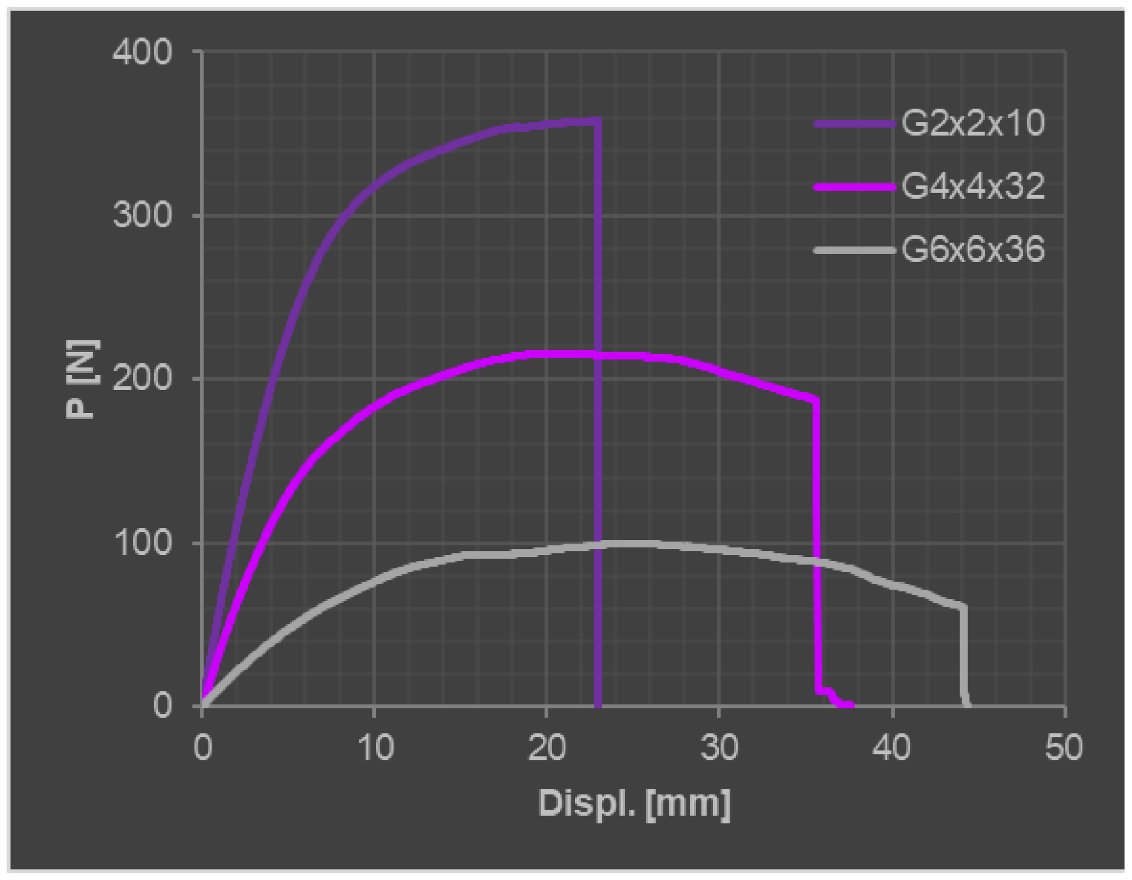
RESULTS & DISCUSSION

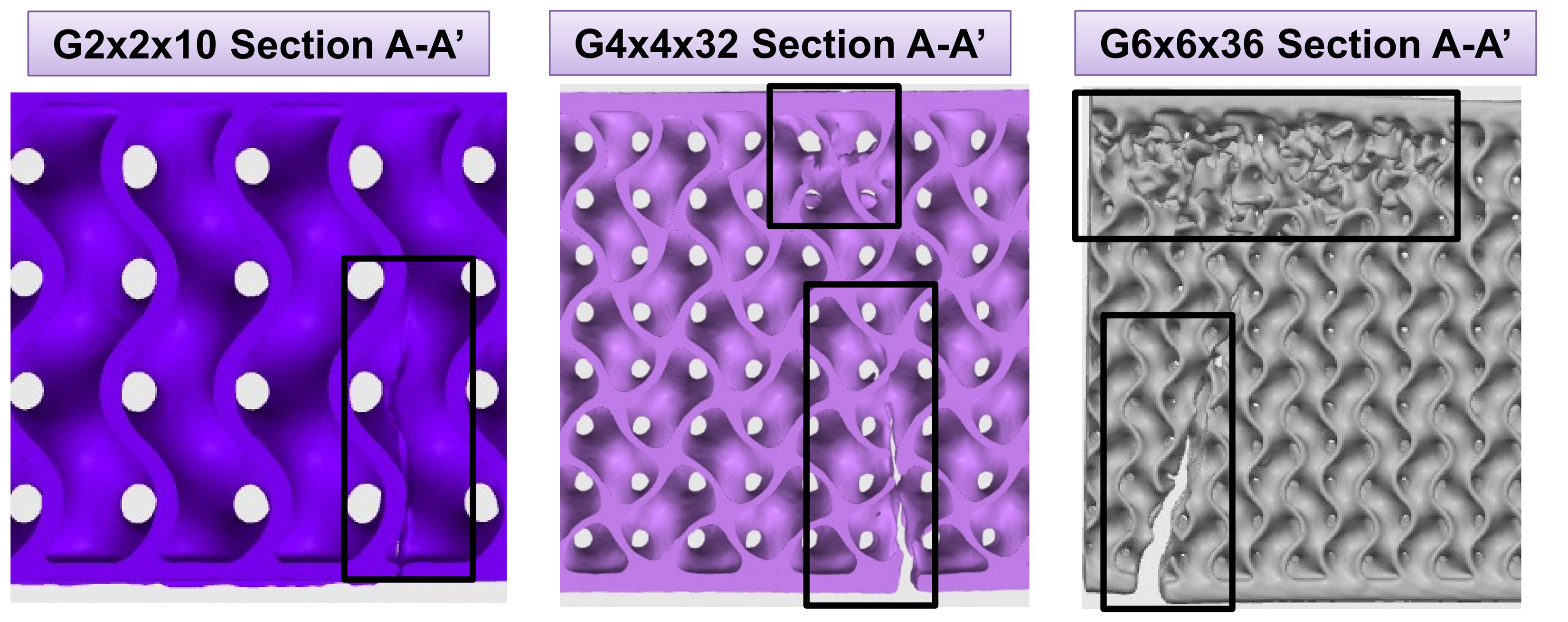


Mechanical Performance



Structure	Max Force [MPa]	Shear Stress [Mpa]	Slope E [Mpa]
G2x2x10	358.241	0.523	52.297
G4x4x32	216.081	0.315	33.870
G6x6x36	95.023	0.139	9.012

mCT scans – section of the crack



The three-point bending tests revealed a clear dependence of flexural performance on unit cell resolution and wall thickness. The G2×2×10 structure, featuring the thickest walls, exhibited the highest maximum force (≈358 MPa), shear stress, and bending stiffness, demonstrating a predominantly elastic response with delayed onset of failure. As the unit cell size decreased and the wall thickness was reduced (G4×4×32 and G6×6×36), both peak load and stiffness dropped significantly, indicating reduced load-carrying capacity and earlier shear-dominated deformation, but they delay to failure. CT scans confirmed that failure initiated within the core for all specimens but progressed more uniformly in the higher-resolution lattices, whereas the thinnest-walled G6×6×36 showed localized buckling and cell wall rupture.