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Research Scholarship for International Graduate Students

Design, Optimization, and Analysis of Cellular Structures Using High-speed Additive Manufacturing

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Abstract

In this study, the author aims to investigate the effect of lattice unit cell dimensions, lattice morphology, and the height of the column on critical buckling load and post-buckling behavior of additively manufactured cellular columns. Lattice unit cells of different dimensions and various morphologies were designed using the unit cell design method. A high-speed 3D printing process (Multijet Fusion) was employed to fabricate the compressive samples for this study. Both experimental and simulation-based studies were conducted to investigate the critical buckling load and post-buckling behavior of various lattice morphologies. Finally, the best performing vertical inclined structure was chosen for further analysis and optimization by redesigning the structure with variable-density. This variable-density density structure was analyzed to achieve the optimal value of critical buckling load.

Design and Fabrication Methods

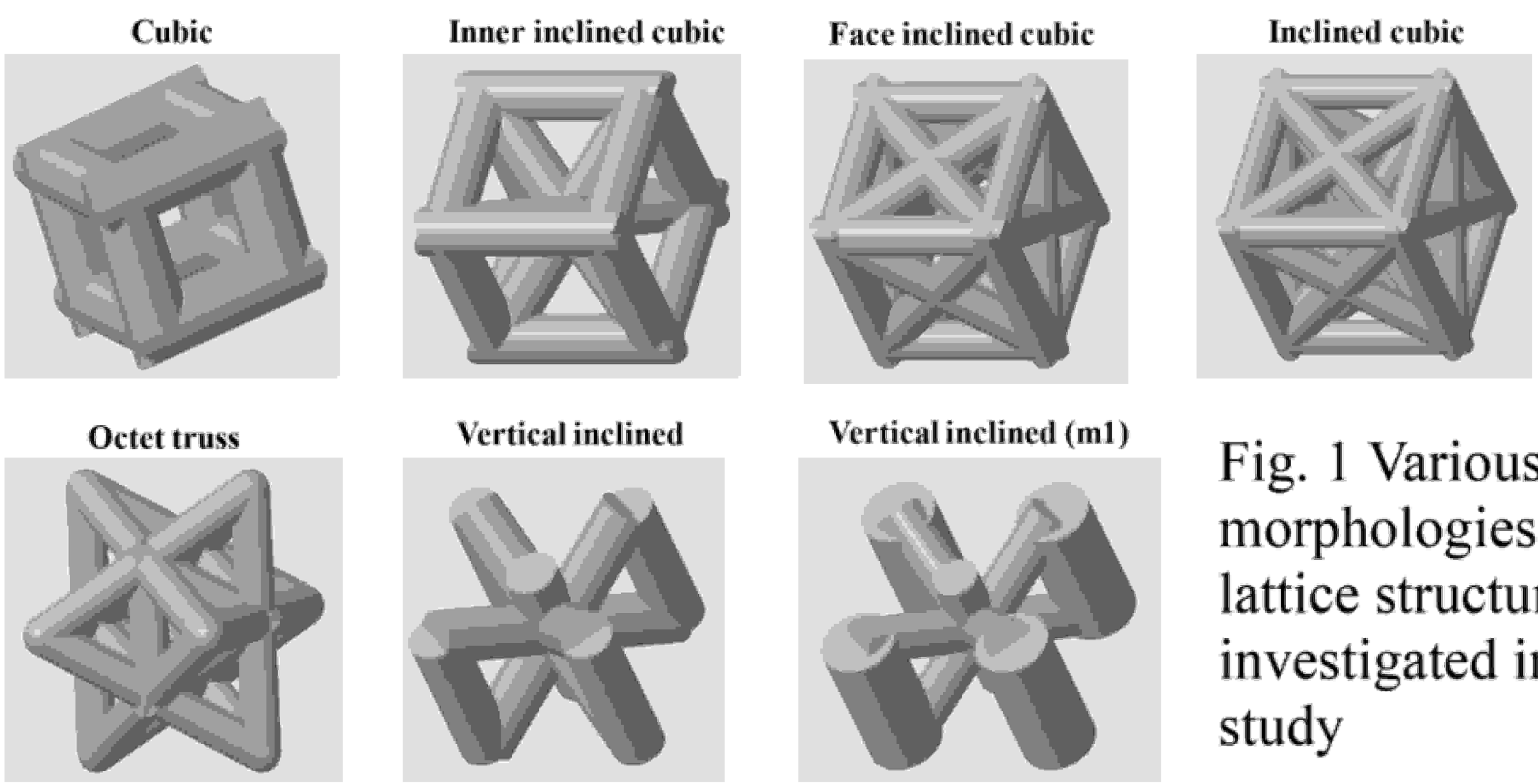

Fig. 1 Various morphologies of lattice structures investigated in this study

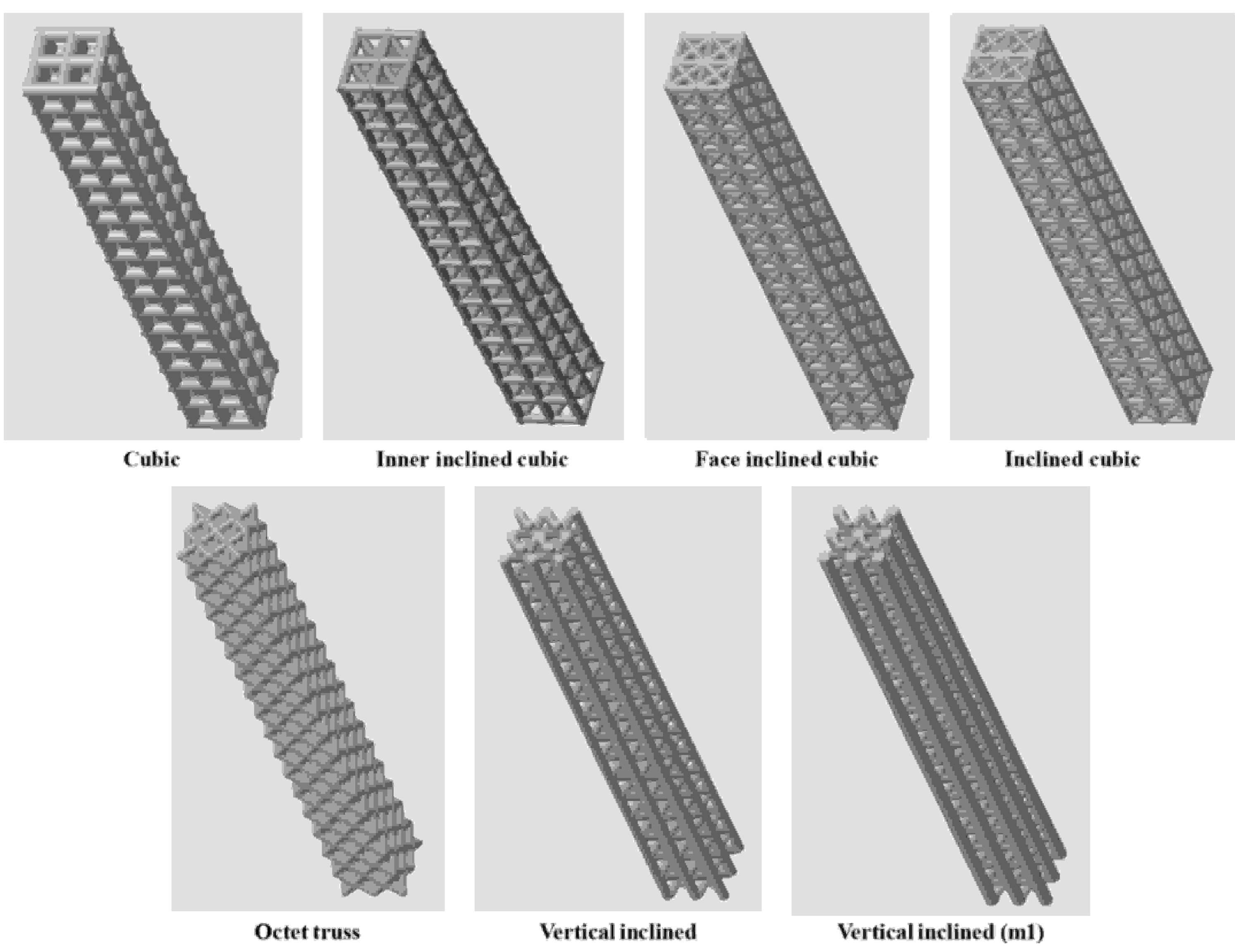

Fig. 2 Uniaxial compressive samples with different lattice morphologies

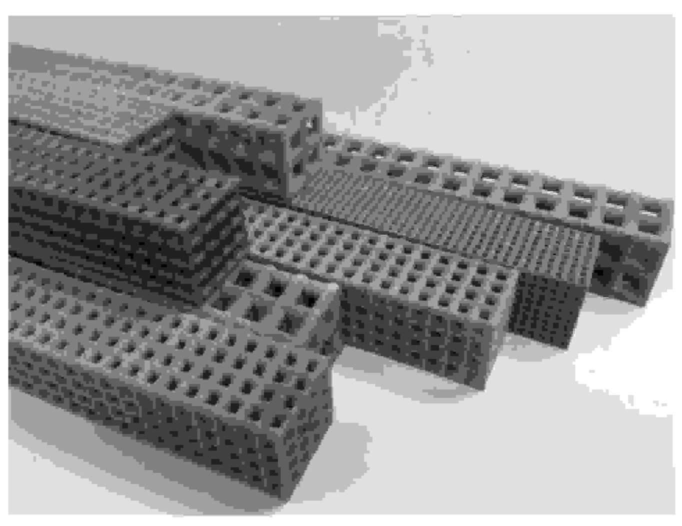

Fig. 3 Samples fabricated using high-speed MJF 3D printer and completely cleaned using sandblasting process

Experimental Testing and Simulations

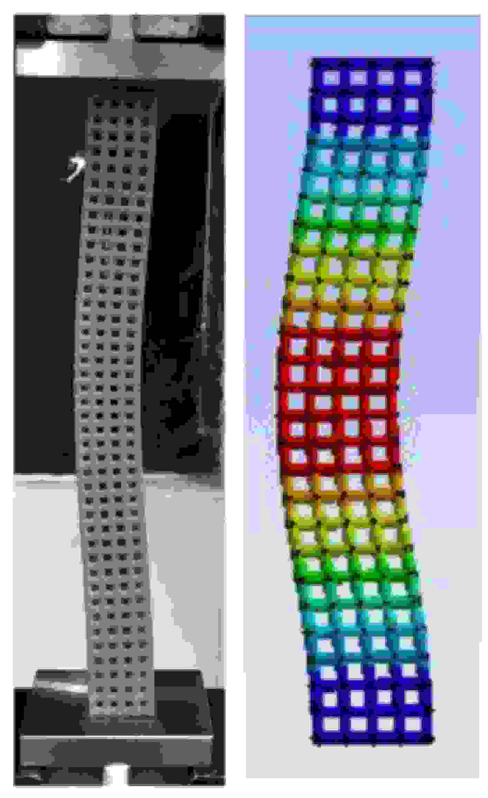

Fig. 4 Uniaxial compression testing (experimental and simulation)

Results and Discussion

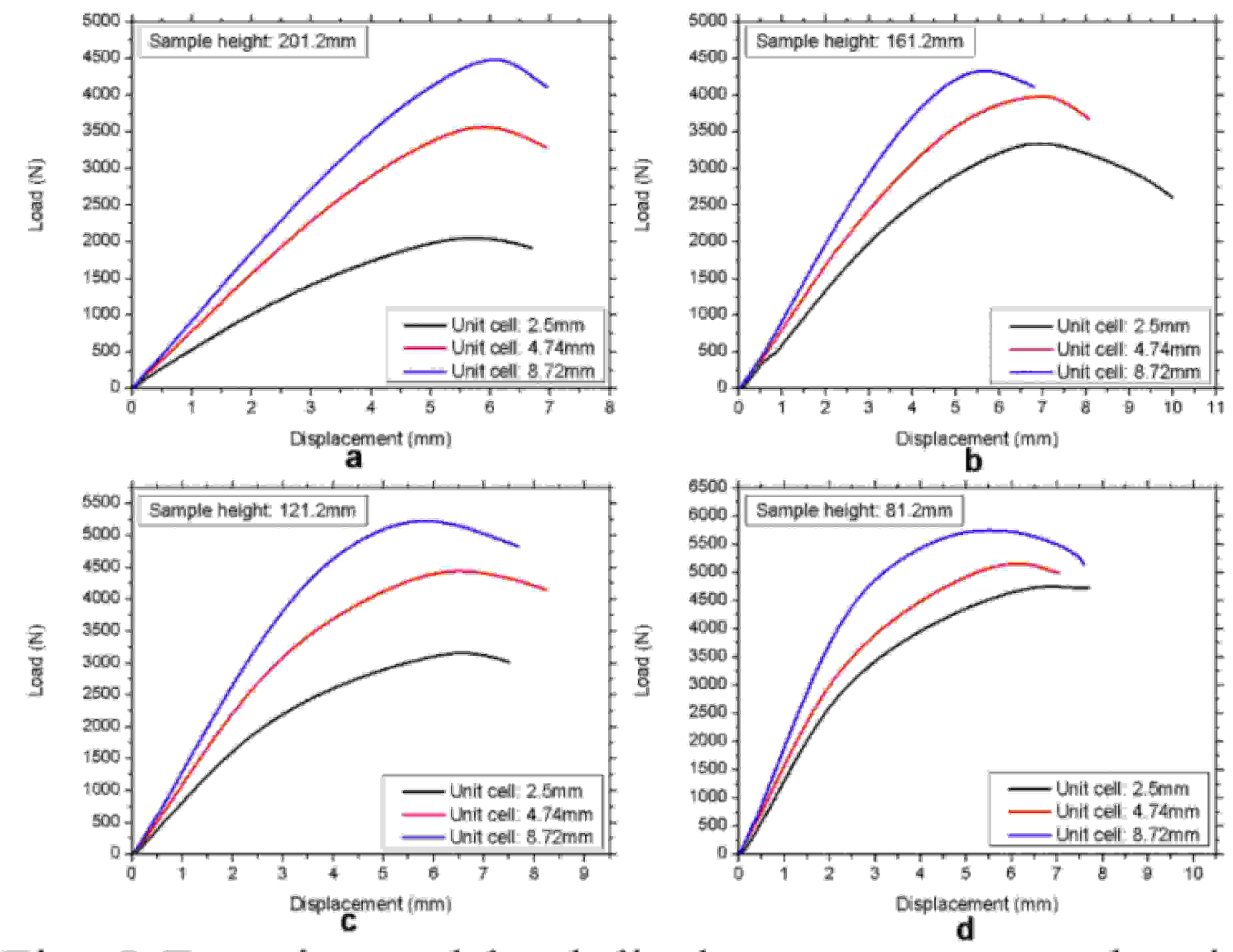

Fig. 5 Experimental load-displacement curves showing the effect of the unit cell sizes on the critical buckling load

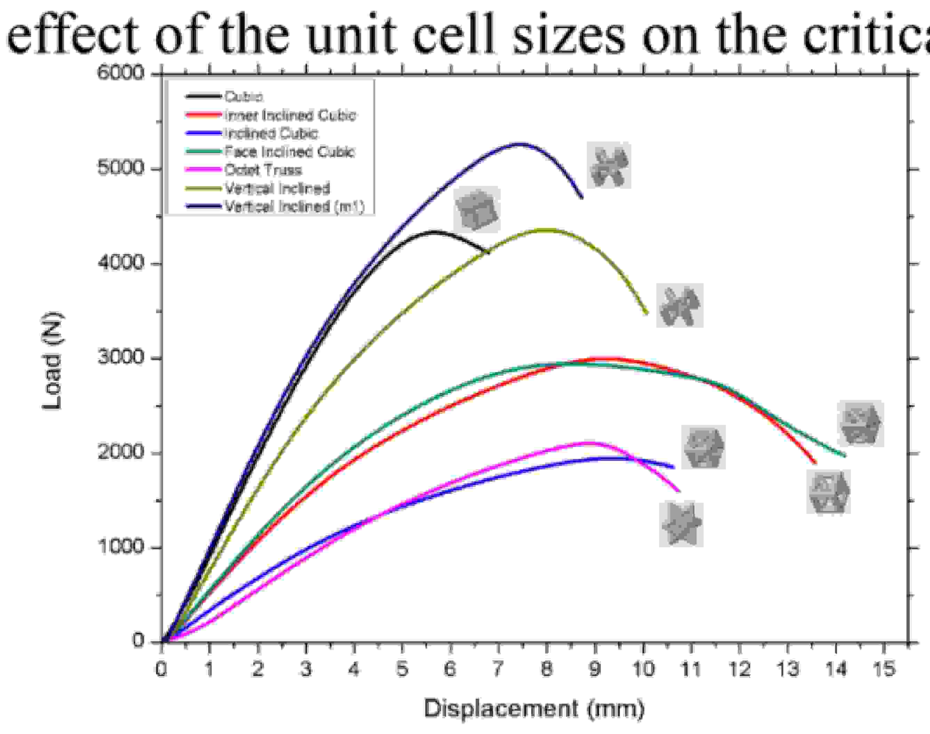

Fig. 6 Experimental load-displacement curves showing the effect of the lattice morphology on the critical buckling load

Summary

The unit cell dimensions, lattice morphology, cellular column height, diameter and position of vertical beams, number of horizontal or inclined beams, location and angle of the beams that supports the vertical beams significantly affect the critical buckling load and post-buckling behavior.

The critical buckling load could be increased by designing variable density cellular columns in which the beams at the outer edges of the column are thicker compared with inner beams.

Selected Publications

1. Nazir A.*, Arshad A.B., Jeng J.Y.*, (2019) Buckling and Post-Buckling Behavior of Uniform and Variable-Density Lattice Columns Fabricated Using Additive Manufacturing, Materials, Vol. 12 Issue 21
2. Nazir A., Jeng J.Y.*, (2019) Buckling Behavior of Additively Manufactured Cellular Columns: Experimental and Simulation Validation, Materials and Design (Accepted)
3. Nazir A., Abate K.M., Kumar A., Jeng J.Y.*, (2019) A State-of-the-Art Review on Types, Design, Optimization, and Additive Manufacturing of Cellular Structures, International Journal of Advanced Manufacturing Technology 104:3489
4. Nazir A., Jeng J.Y.*, (2019) A High-Speed Additive Manufacturing Approach for Achieving High Printing Speed and Accuracy, Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 0954406219861664

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