Analyzing the Impact of Various 3D Printed Infill Patterns on the Tensile Strength of a 3D Print Relative to Its Weight and Orientation

Kline, Brady (School: The Villages Charter High School)

3D printing has the ability to control the internal structure of a product. Published research has not determined the strength-to-weight ratio of infill patterns. The isotropy of infill patterns is also debated. Five infill patterns and their respective tensile strength relative to their weight and orientation were investigated. The grid, hexagonal, gyroid, and octet patterns were tested in addition to a novel trabecular lattice that mimics the randomized nature of human spongy bone. The tensile strength of the models was measured using finite element analysis in nTopology and a universal testing machine. The Z-axis grid and hexagonal patterns consistently showed the highest Young's Modulus-to-weight ratio in nTopology. The 80% Trabecular (1) infill showed the highest yield strength and Young's Modulus-to-weight ratios at 3.1729 MPa/g and 278.5893 MPa/g respectively, on the universal testing machine. An ANOVA test determined the Trabecular (1) group had significantly higher strength-to-weight ratios for Young's Modulus, yield, and ultimate strength. A two-way t-test comparing the Y and Z-axis groups for each infill yielded P=0.005 for hexagonal and P=0.0655 for grid, suggesting greater anisotropic behavior for the 2D infills compared to 3D infills. The results suggest use for the trabecular lattice as a high strength-to-weight ratio infill pattern for use in additive manufacturing. The grid and hexagonal Z-axis infills could be used to provide extra support along specific orientations. Further research could optimize the strength-to-weight ratio of the randomized trabecular lattice beyond the results seen in this research.

Awards Won:

Florida Institute of Technology: Full Tuition Presidential Scholarship