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Conceptualization of Adaptable Light Weighting Methodology for Material Extrusion Processes

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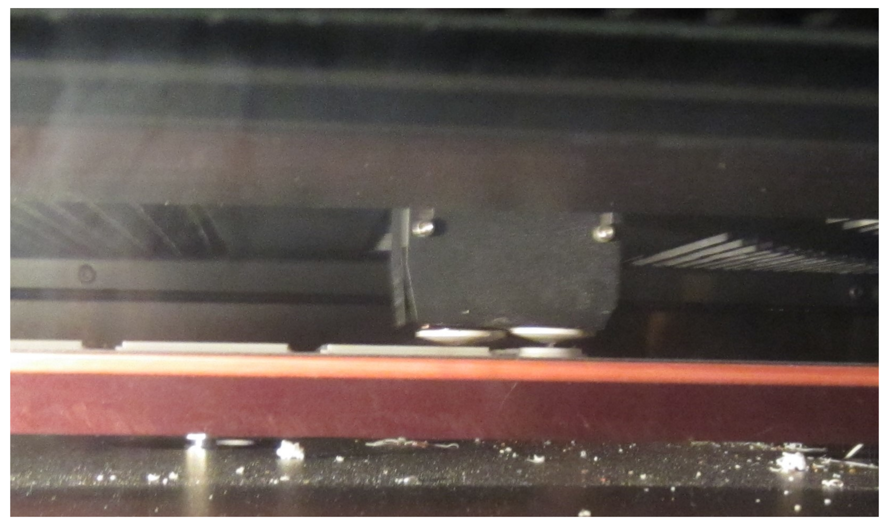
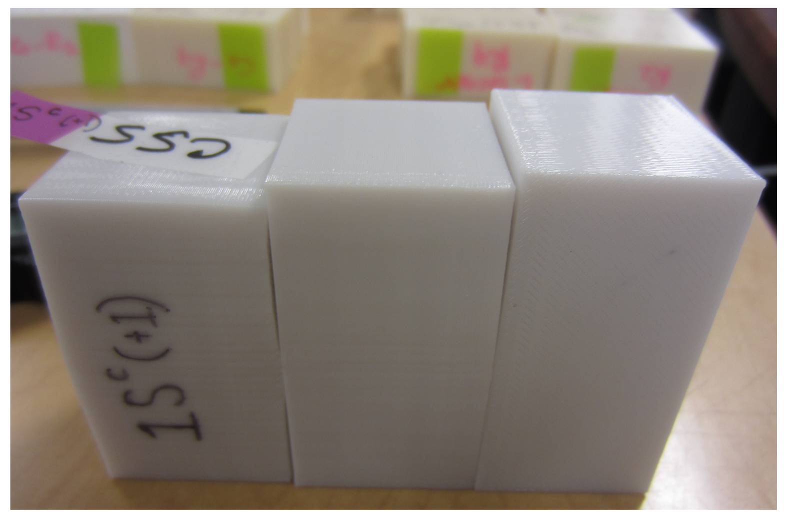
PROJECT IMPORTANCE

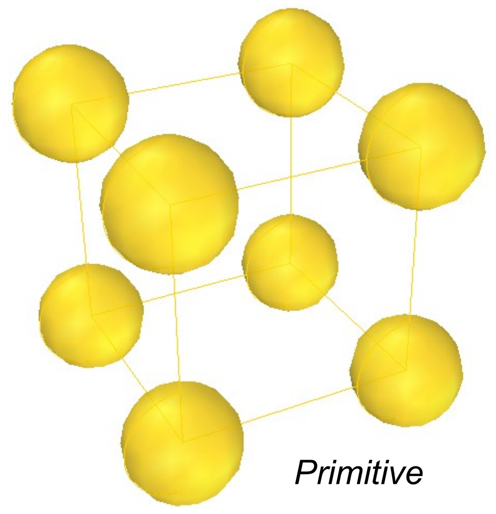
3D Printing, the Technology of the Future.

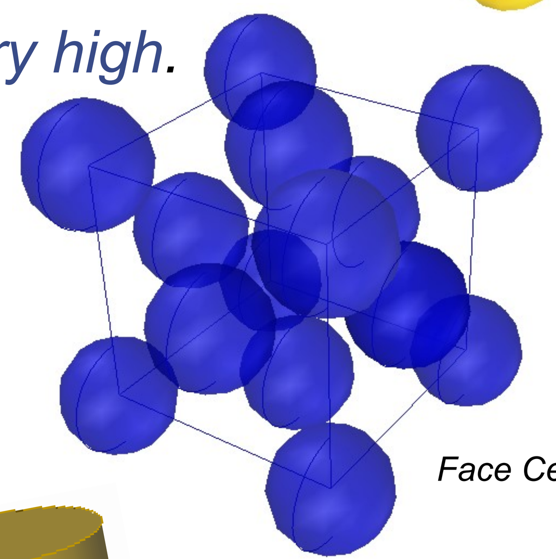
Material extrusion processes such as 3D printing take part modelling to the next level. This technology allows users to print actual 3D models of computer generated designs.
No assembly required, nice surface finish, virtually no human interference necessary,

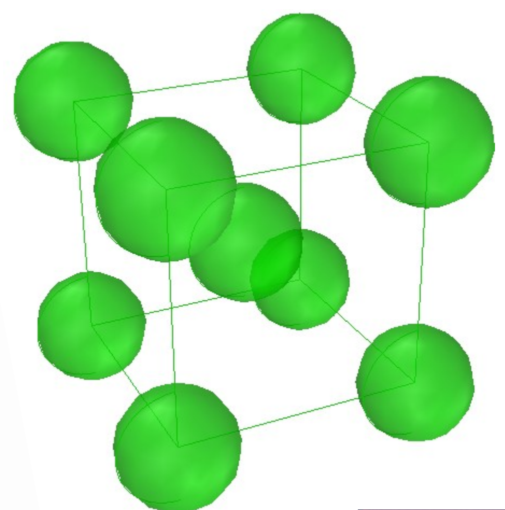
What's the catch?- On top of initial start-up costs, material costs are very high.






Primitive

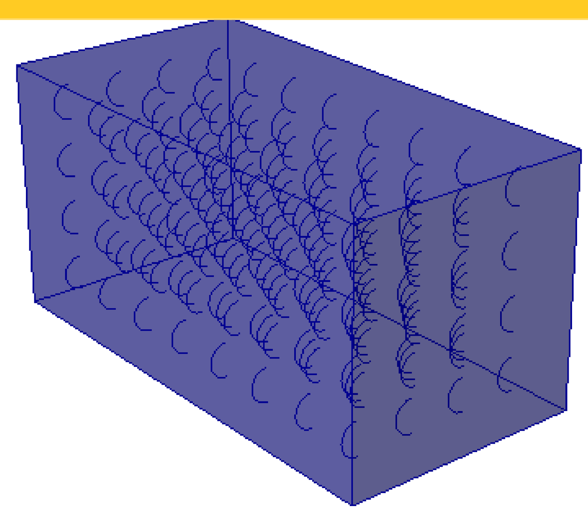

Face Center

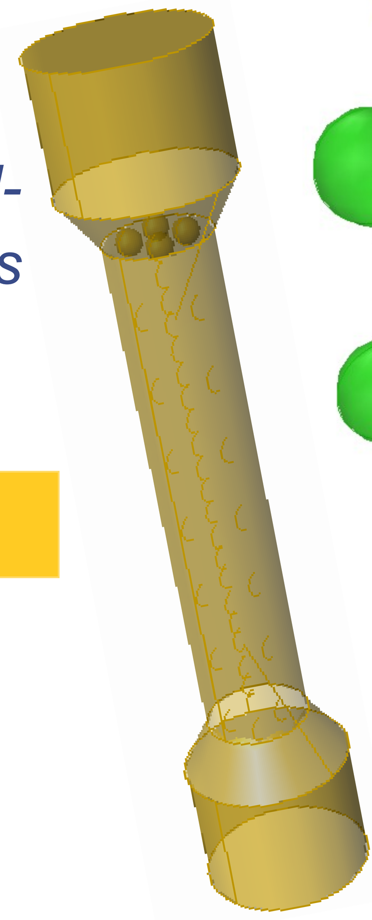

Body Center

Efficient light weighting methods can make 3D printing more affordable while conserving model strength; its exploration brings this technology one-step closer to everyday use.

METHODOLOGY

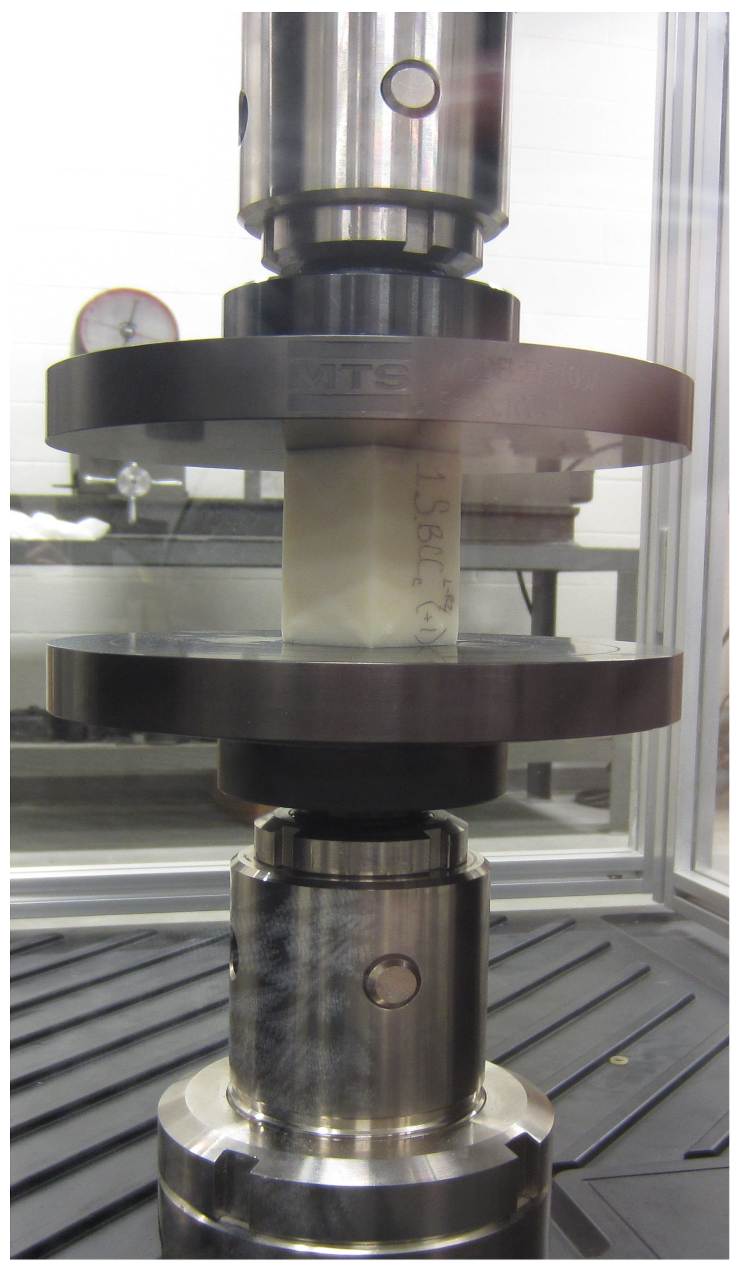
This research aims to find an optimal solution between saving material while keeping samples strong. It explores one method called 'Spongefication' which explores the implementation of spherical voids.





Models generated using Grasshopper, viewed in the 64-bit version of Rhinoceros

The idea behind this: if you have circular voids, the stress on those areas will be distributed evenly in all directions.



Above: Compression model seen during testing, using the MTS Criterion Model 43 .

The biggest feat in creating these models was making them adaptable and simple to understand.

Three base models were developed from metallic crystal structures, which take primitive, body-center cubic, and face center cubic orientations.
To create models that could be changed within instants the Grasshopper graphical add-on program was utilized to relate all the variables.

The variables kept constant within this testing were the subject dimensions, the shell width, and the material used (which is polycarbonate for the testing presented). Varying variables include the spherical hole radius (either 4mm or 2mm), the hole distributions (primitive, FCC, or BCC), and the hole counts in the X,Y,&Z directions. The models explored are 'loose' or have less pores (3 holes in XYZ for radius of 2mm or 2 in XYZ for r=4mm) or deemed 'compact' or with more voids (4 holes in XZ & 8 Y for r=2mm or 2 in XZ and 4 in Y for r=4mm). Compressive models were 26.8x26.88x57.2 mm^3 in dimension.

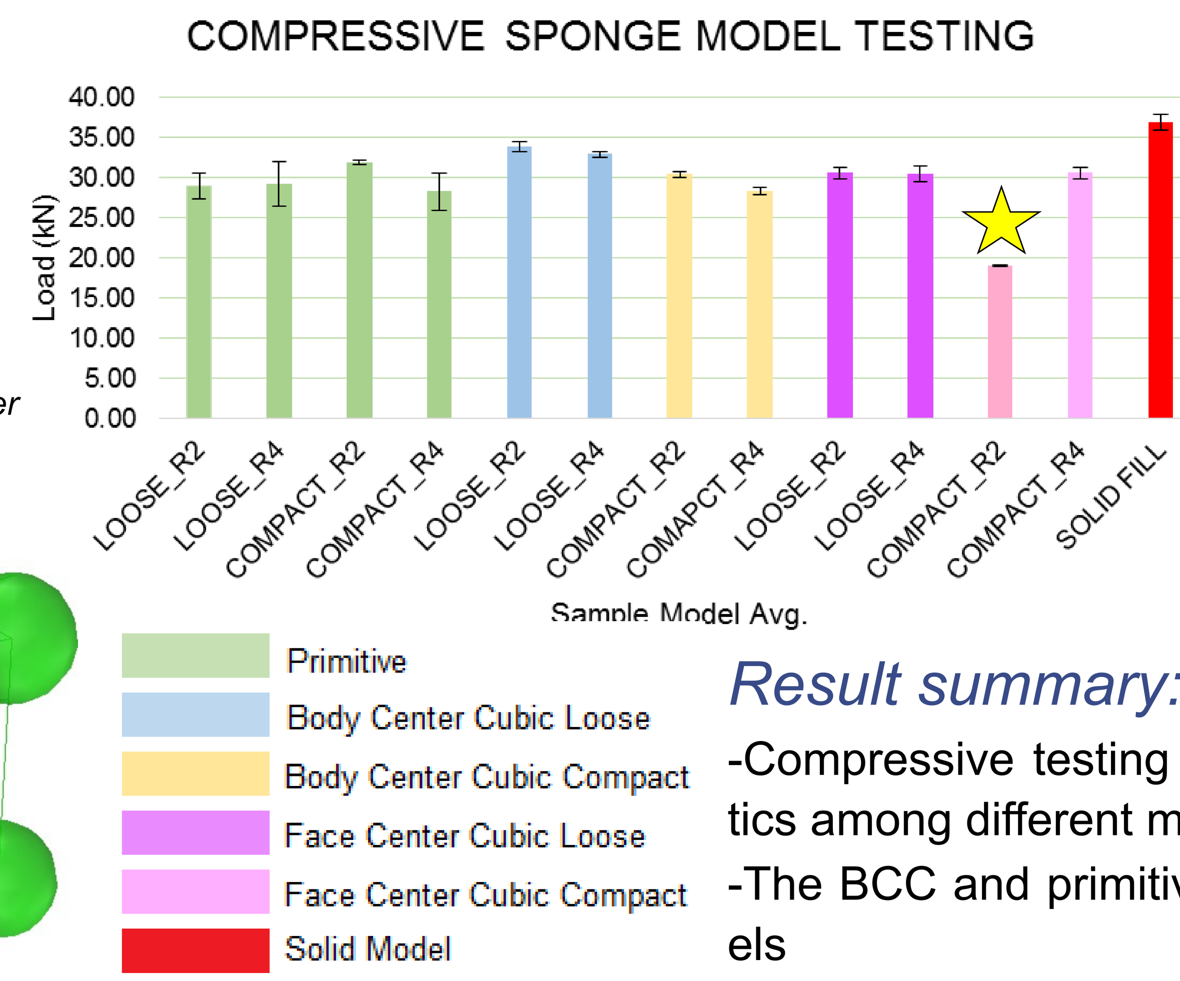
Once the base model designs are established, three copies of each model are printed and then tested, using compressive and tensile testing methods.

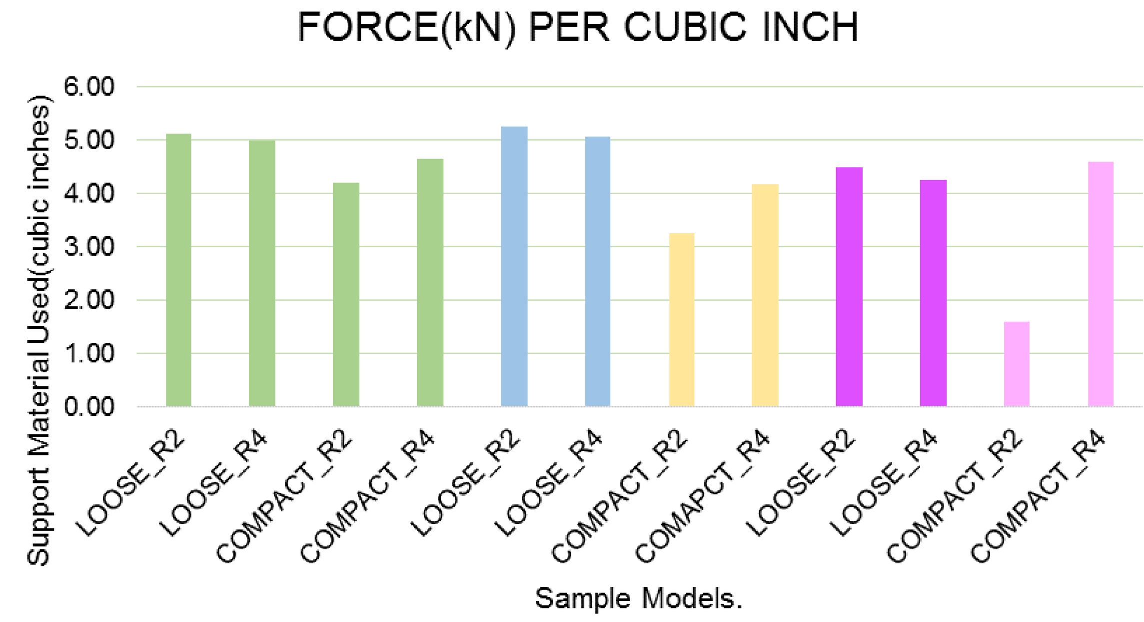
RESEARCH QUESTION

How can we efficiently make 3D printed samples lighter?

This project aims to create a user-friendly programmable light weighting method for various internal structures, and to explore the associated mechanical properties for ABS and polycarbonate materials.

FINDINGS





Result summary:

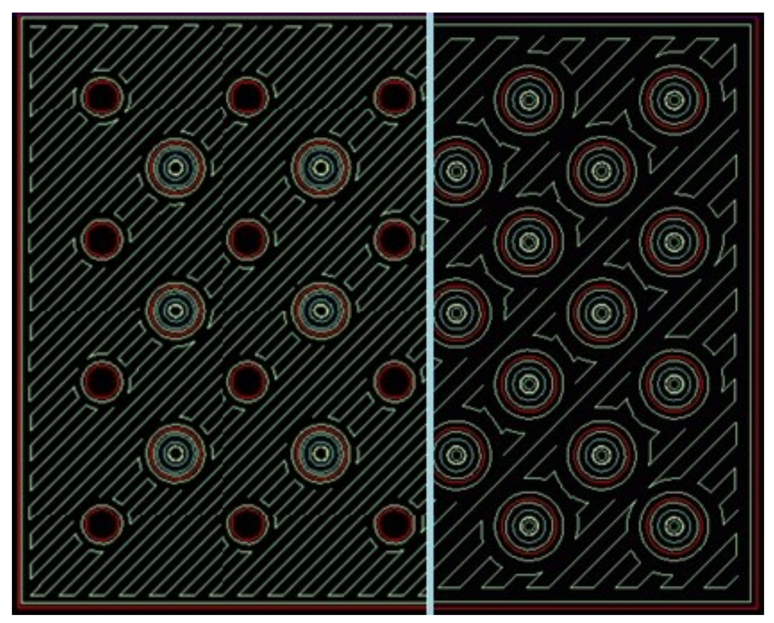
-Compressive testing of the printed samples show varying strength characteristics among different models

-The BCC and primitive models exhibited comparable loadings to the solid models

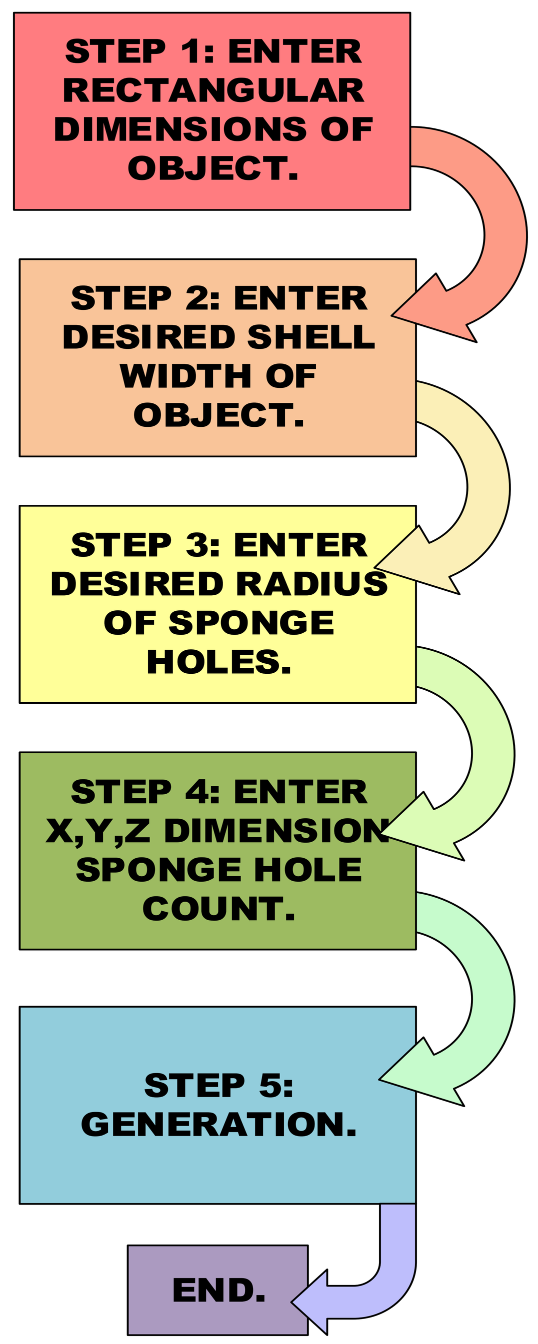
-Unexpected failure was met with the FCC models, assumed to be caused by the tool path taken during the printing process

-Due to 'jumps' or discontinuities in the tool path during printing, unexpected voids were created within samples. ☆ Approximately 12% of the material that should have been deposited for the FCC samples was not. ☆

-More testing will be conducted to explore the tensile properties of this light weighting option and to get a better understanding of its related mechanical properties



Left: Cross-section of the BCC model compared to a FCC model (featured on the right) seen in the Insight software before printing. Observable discontinuities are seen around circular voids in the path, which are more frequently seen in the FCC models.



IMPACT

Future impacts of this research includes first of all the exploration of further light weighting options. One in particular which includes offset internal support rods which are slightly fused together.

Due to the significant findings in this research which revolve around the tool path taken in the printing process, different tool paths are being explored. This will require the creation of a whole new algorithm, computer program, and possibly a different nozzle head or the development of a whole new 3D printer.

ACKNOWLEDGMENTS

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