3D PRINTING ORIENTATIONS AND HOW IT AFFECTS MATERIAL PROPERTIES

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OBJECTIVE

DETERMINE THE TENSILE PROPERTIES OF POLYLACTIC ACID (PLA) WHEN PRINTED AT DIFFERENT ORIENTATIONS USING FUSED DEPOSITION MODELING (FDM)

Zero Degrees (5 specimens)  
90 Degrees (5 specimens)  
45 Degrees (1 specimen)
EQUIPMENT

- Creality Ender 3 Pro
- MTS Criterion Model 43
- Ruler
- Neiko Calipers
- Hatchbox PLA

AUTODESK® FUSION 360™

Cura
WHY IS THIS IMPORTANT?

- FDM is a process of additive manufacturing where extruded layers of material builds the object.
- The print orientation changes the direction of the layers in the print.
- It is expected that layers parallel to the tensile force would perform best. (0-degree print orientation)
THIS PROJECT CONSISTS OF THREE PHASES

- **Design and Planning**: 09/2020
- **Preparation and Testing**: 10/2020
- **Analysis and Presentation**: 11/2020
**PHASE 1: FUSION 360 DESIGN**

- Fusion 360 is made by Autodesk
- It is easy to use for 3D modelling
- The specimen is modelled in mm
- The specimen was modelled to ASTM D 638-03 Type 1 standards
PHASE 1: CURA 4.7.1 DESIGN

Cura is an open-source slicer made by Ultimaker. It is used to develop G-code for use in different types of additive and subtractive manufacturing machines.

This Cura profile was pre-developed for the Ender 3 Pro and only slight modifications made.
PHASE 1:
CURA 4.7.1

The three orientations in Cura, Cura automatically creates supports based on the settings in the previous slide.

Once the orientation is set you click slice and the G-code is prepared.
PHASE 2: THE FINAL PRINTS

- After generating the G-Code the prints were made and shown above.
- The prints were marked for tension testing, and in-fills specified.
PHASE 2: TENSION TESTING

- Using the materials testing lab at FSU Panama City, the specimens were tested on the MTS tension testing machine.
- Some errors from this phase could originate from the cylindrical chucks, the initial loading (but this was accounted for) and possible machine errors from not being properly calibrated.
PHASE 3: RESULTS
ACQUISITION AND ANALYSIS

- This phase consisted of the evaluation of the 11 specimens and compared the material properties in tensile stress.

- As shown the specimens that faired best were the 0-degree specimens.
## DIRECT COMPARISON

Shown above is a direct comparison of the results across all 11 specimens.
EXPLANATION

0-Degree specimen
- As shown this specimen did not fail catastrophically
- This may be due to internal micro-structural failures and would not resettle in the tension tester to catastrophically fail.

90-Degree specimen
- This specimen did fail catastrophically along the layer line
THE 45-DEGREE SPECIMEN

- Initially I believed this would be the stronger out of 90 and 45
- This failed at a lower stress in the round
- It may be due to internal micro-failure at this location
- Or initial loading caused a slight stress concentration that caused failure at the round near the chucks
- This was the weakest of the specimens
According to the data, the orientation of loaded prints is important to consider as the 0-degree specimens performed the best.

The 90-degree specimens did not do much worse but if it is an important application then it is worth the time to consider orientation.

The 45-degree specimens results were surprising and would be worth to check with another specimen.

Possible errors include, my measurements, printing defects, my calculations, using a cylindrical chuck.
REFERENCES


ASTM D638-03 – SOURCED 11/20/2020


QUESTIONS?