

Mechanical Strength of PLA Fabricated by FDM as a Function of Layer Orientation

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This work evaluates the influence of layer orientation on the tensile strength of PLA specimens manufactured by Fused Deposition Modeling (FDM). PLA is one of the most widely used thermoplastics in additive manufacturing due to its ease of processing and favorable mechanical properties. However, the layer-by-layer deposition process generates anisotropic behavior, where the mechanical response depends on filament orientation relative to the applied load.

The main objective of this research was to determine how different layer orientations affect the tensile behavior and structural performance of PLA specimens manufactured by FDM.

For the experimental procedure, ASTM D638 Type V specimens were designed and fabricated using a Raise3D Pro3 printer. The printing parameters remained constant throughout the study, including a layer height of 0.2 mm, 50% infill, a nozzle temperature of 215 °C, and a printing speed of 50 mm/s.

Four different layer orientations were evaluated: 0°, 90°, 45°/135°, and 0°/90°. Tensile tests were performed on multiple specimens for each configuration, and the reported values correspond to the average tensile strength obtained experimentally.

The results demonstrated that layer orientation significantly influences the mechanical performance of PLA. The 0°/90° configuration achieved the highest tensile strength, reaching an average value of 35.5 MPa. This behavior is associated with improved stress redistribution and better resistance to interlayer crack propagation. In contrast, the 90° orientation exhibited lower mechanical performance due to premature interlayer failure, since the applied load acts perpendicular to the deposited filaments.

Overall, the experimental results confirmed the anisotropic behavior of FDM-printed PLA and demonstrated that layer orientation plays a critical role in stress transfer and structural integrity. Therefore, PLA manufactured by FDM should be analyzed as a laminated structure rather than as an isotropic material.