Comparative Strength Analysis of 3D-Printed PLA Plates with Different Infill Patterns

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Abstract
I tested 4 different infill patterns that could be used while 3d printing a object.I am conducting a test to determine the strength (load capacity) of four different infill materials in PLA (Polylactic acid) with metal fibers when printed using a 3D printing. The gyroid 3d infill preformed best outperforming the other infills by over 10N.

Induction
Infill is a critical component of 3D printing, as a substantial portion of a print can consist of infill—commonly up to 50%[1], though typically around 20%. Since a majority of the strength of a 3D model arises from its infill, which constitutes most of the volume, selecting the appropriate infill is a key factor in determining whether a model achieves sufficient mechanical strength. Furthermore, PLA Metal is a less commonly used variant of PLA in 3D printing and is less extensively studied than standard PLA. Consequently, users of PLA Metal have limited empirical data specific to this material, making the selection of optimal infill parameters for particular models more challenging.

Methodology

Material information

For this test I will be using Bambu Labs PLA Metal (Iron Gray Metallic 13100) on a Bambu Labs P1P Printer. The test samples will 75x30x50 (mm) in size with printer settings: **Layer Height** 0.2 mm; **Wall Loops** 2; **Sparse Infill** 15% **Grid** pattern; **Top/Bottom Layers** 5/3; **Outer Wall Speed**200 mm/s; **Travel Speed** 500 mm/s; **Normal Acceleration** 10000 mm/s2; **XY Distance** 0.35 mm; and **Z Distance**0.2 mm (for supports, if enabled), utilizing a **Prime Tower** (35 mm width, 45 mm3 volume) for multi-material prints. The different infill shapes that I used were: **Grid, Gyroid, Honeycomb, and Triangular.**

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[1]Xometry (2023) Infill in 3D Printing: Definition, Main Parts, and Different Types online Available at: https://xometry.eu/en/infill-in-3d-printing/

All data was performed at home and accuracy cannot be guaranteed.c

Test Procedure

The test will be conducted using the test samples, a vice, a baggage weight measure, and an electronic caliper. Each test sample will be placed on the vice, maintaining the same position for all samples. The baggage measure and caliper will then be used to apply a downward force on the samples. The maximum weight that each sample can withstand before bending more than 3 mm or breaking will be recorded using the caliper. This procedure will be repeated for all four samples. To ensure the fairness of the test, only the infill pattern of the 3D prints will be modified, and all samples will be printed simultaneously. This approach maintains consistent conditions, such as humidity, which could potentially affect the results. The entire process will be repeated three times to ensure data accuracy, and the mean of the three datasets will be used for final analysis.

Results

Table

Graph

All data was performed at home and accuracy cannot be guaranteed.c

Discussion

In the test, Gyroid infill demonstrated the most exceptional performance, surpassing the closest infill Grid by over 13N. This remarkable result can be attributed to the unique shape and design of Gyroid infill, which incorporates interlocking parts that distribute stress in all directions. This design principle enables Gyroid infill to achieve near-isotropic strength, making it an ideal choice for real-world 3D printing applications where strength, particularly in all directions, is paramount.

Conclusion

In conclusion, among the four different infill tests conducted, the Gyroid infill demonstrated the most favorable results. Consequently, for modules that necessitate enhanced strength, the Gyroid infill is the optimal choice.