

In the field of 3D printing, warping is a major issue, especially on large prints. I tested ways in which warping on large 3D printed models could be minimized to simplify the printing of large architectural models. Warping occurs when the heated printing material cools unevenly, causing tension in areas of the model. The model relieves this tension by bending under the stress. I tested five different filaments of varying types in combination with differing print temperatures, heated build plates, and cooling fans in order to determine the ideal combination of factors that would produce the smallest amount of warping on a large print. The filament types tested were Carbon Fiber, PETG, Laybrick, Ninjabflex, and PLA. PLA is the most commonly used printing material, so it was used in this study as a control. A sixth filament, Moldlay, had to be omitted from the study due to technical constraints of the printer. I separated the testing period into three stages. For all three stages, the printer used was the Lulzbot TAZ. The TAZ has a 12"x12"x9" build area, a heated bed, and a variable speed cooling fan. The software used to control it, Cura, allows for manual adjustment of factors such as the bed and print temperature and the fan speed. The same test model, a castle, was used in all print trials. Warping was classified in three separate ranges. Any print that warped to a height of 0.5 cm or lower was classified as low warping, any in the range of 0.6 cm to 1.0 cm was classified as medium warping, and any warping that reached a height greater than 1.0 cm was classified as high warping. A micrometer was used to measure warping height. The first stage involved testing each filament at its minimum, median, and maximum recommended print temperatures, with no other cooling or heating factors involved. There were fifteen trials in this stage, and any materials that demonstrated no warping at any temperature during this stage were omitted from stage two. The second stage involved testing any filaments that demonstrated warping in stage one in different combinations of cooling and heating factors, to determine which combinations produced the lowest amount of warping. There were a total of thirty-six trials in this stage. Stage three involved the testing of only combinations that had produced no warping during the first two stages. Filament type was changed after the first three layers of the print in each of these trials to determine whether or not this could cause the model to warp. This factor was tested because when printing a large model, it would be more cost effective to use the more expensive, warp resistant materials to print the first few layers, where warping is most likely to occur, and then use a less expensive filament for the rest of the model. From these tests, it was determined that three filament types, Laybrick, PETG, and Carbon Fiber, were the least likely to warp on a large architectural print. The heated build area was the factor found to contribute the most to reducing warping in every filament tested, while factors such as the cooling fan and the temperature of the filament itself were found to be comparably negligible. These findings could result in greater ease of printing large models, opening up the possibilities of what types of models are viable for 3D printing.