# Which print orientation makes a replacement part strongest?

Asked 3D Content Team
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**Abstract.** Lay the load along the layers: Bambu Lab PETG Basic pulls 51 MPa in XY and 35 MPa in Z, and CNC Kitchen's PLA coupons gained 27 percent tilted to 45 degrees.

**Keywords:** part-strength, replacement-parts, home-repair

**Table 1.** The numbers

| Material (product, manufacturer) | Tensile XY (MPa) | Tensile Z (MPa) | Bending XY / Z (MPa) | Impact XY / Z (kJ/m²) |
|---|---|---|---|---|
| PLA (PLA Basic, Bambu Lab) | 35 ± 4 | 31 ± 3 | 76 ± 5 / 59 ± 6 | 26.6 ± 2.8 / 13.8 ± 0.9 |
| PETG (PETG Basic, Bambu Lab) | 51 ± 1 | 35 ± 6 | 75 ± 3 / 56 ± 4 | 34.2 ± 4.1 / 10.5 ± 1.8 |
| Carbon-fiber nylon (PA6-CF, Bambu Lab) | 102 ± 7 | 48 ± 6 | 151 ± 8 / 80 ± 7 | 40.3 ± 2.5 / 15.5 ± 1.7 |
| PETG (Prusament PETG, Prusa Polymers) | 47 ± 2 printed flat | 18 ± 4 interlayer adhesion | 66 ± 2 flat | no break, unnotched |

## 1 Which print orientation makes a replacement part strongest?

The one that puts the load along the layers rather than across the layer bonds. Bambu Lab's PETG Basic pulls 51 MPa in XY and 35 MPa in Z. When the load must cross layers, tilt the part instead of standing it up: CNC Kitchen's PLA coupons went from 31 MPa upright to 40 MPa at 45 degrees.

### 1.1 The numbers

Bambu Lab figures are ISO 527, ISO 178 and ISO 179 on specimens printed at 100 percent infill. The Prusament interlayer value is Prusa Polymers' own method. Its "vertical" tensile specimen (50 ± 1 MPa) stands on edge with the layers still along the pull, so it is not a Z figure.

### 1.2 Why the direction matters

A printed part is a stack of welded lines. Along a line the plastic is close to its bulk strength. Between layers the bond was made with no pressure, and Protolabs Network's guide puts XY tensile strength at typically 4 to 5 times the Z value. The data sheets above show a smaller gap, from 11 percent lost in PLA Basic to 62 percent in Prusament PETG's interlayer test, so the penalty depends on material and settings.

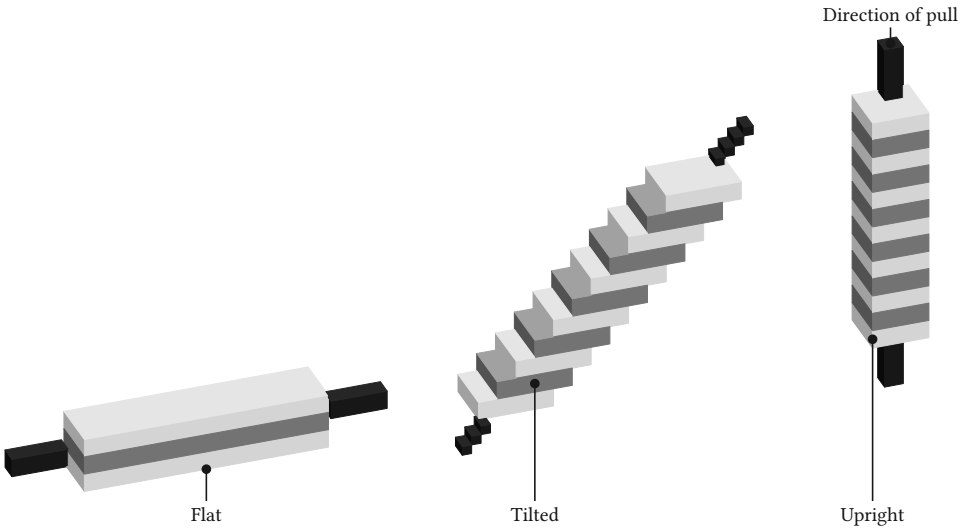



**Figure 1.** Printed flat, the pull runs along every layer; tilted, it crosses the layers at a slant; upright, it pulls straight across the bonds between them.

Impact suffers more than tension. PETG Basic keeps 69 percent of its tensile strength across layers but only 31 percent of its impact strength. A clip that gets knocked wants its layers along the blow even more than a bracket that gets pulled.

### 1.3 The rule for a loaded part

1. Find the load. A hook is pulled, a bracket is bent, a peg is sheared. If the part has broken once, the crack shows the direction.
2. Lay the part so that load runs along the layers. Protolabs Network gives one rule per load. Tension: layers parallel to the force. Bending: the shell lines along the length of the bend. Shear: a horizontal orientation, so the force must cut through strands rather than slide two layers apart.
3. When the geometry forces a cross-layer load, tilt rather than stand. CNC Kitchen printed PLA coupons at 0, 30, 45, 60 and 90 degrees on a Prusa CORE One at 0.2 mm layers: 63, 44, 40, 36 and 31 MPa. Strength does not fall in a straight line between flat and upright but follows an S-shaped curve, so CNC Kitchen's advice is to aim for at least 45 degrees.
4. If the weak direction cannot be avoided, add section: a wider neck, more perimeters or a tougher material. Carbon fiber helps XY far more than Z, as the PA6-CF row shows.

### 1.4 Where orientation costs you elsewhere

Tilting a part adds supports and support scars, and a face that was flat on the bed now carries layer steps. Dimensional accuracy moves too, since Prusa quotes different figures for Z and XY, as the measuring guide covers. For a part that must both fit and hold, print the fit-critical face flat only when the load allows. Otherwise print a test coupon in the tilted orientation and measure the coupon.

CNC Kitchen's own example was a vacuum adapter: tilting it raised the layer strength by roughly 30 percent without changing the material or the settings. The replacement parts guide covers the material choice that comes next.

## References

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