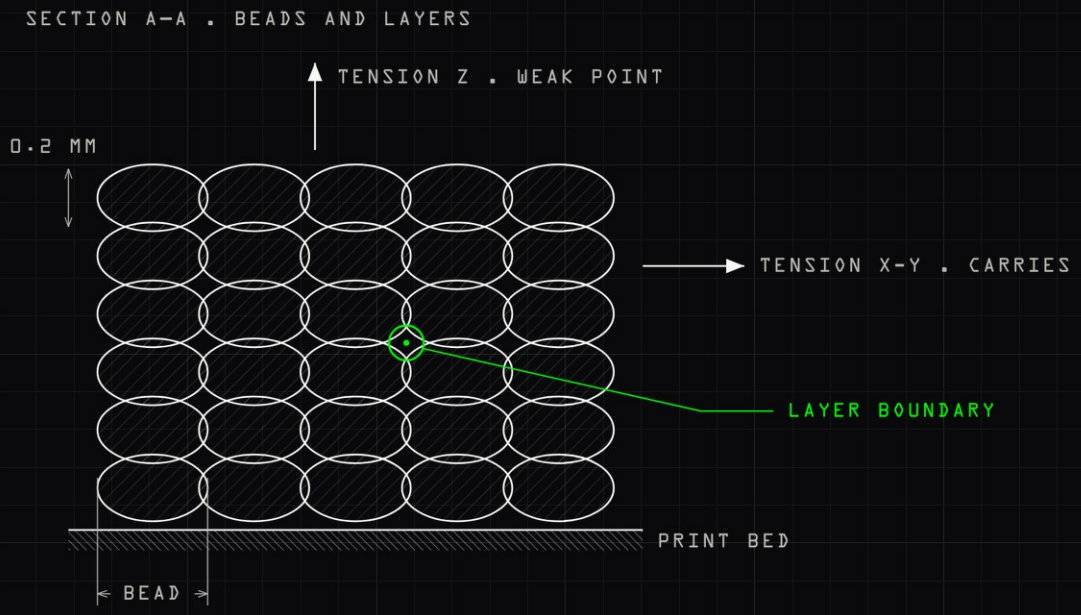
FIBERTHREE



WHITE PAPER . WP004

DESIGN FOR MANUFACTURING

How are parts designed so that they print reliably and perform in use?

DOCUMENT

WP004

FIBERTHREE WHITE PAPER

DATE

11.2026

VERSION 1.0

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00 . EXECUTIVE SUMMARY

How strong an FFF part is depends on direction. DLR measurements on F3 PA-CF Pro show a tensile strength of 115.7 MPa along the bead, 63.6 MPa across it and only 21 to 29 MPa in the build direction. Design for manufacturing therefore mainly means: put loads in the build plane and keep the weak points of the process out of the load path.

This paper sums up the rules needed for this:

A checklist at the end sums everything up for release.

AT A GLANCE

- **Orientation:** main load in x-y, no tension across layer boundaries
- **Walls:** multiples of the bead width, rather more perimeters than more infill
- **Overhangs:** 45° rule, chamfers on lower edges, teardrop shape for horizontal holes
- **Fits:** allow clearance, finish precision dimensions, plan for shrinkage from annealing
- **Joints:** threaded inserts for frequent assembly, snap fits printed flat
- **Warping:** round corners, use fibre-reinforced grades

Recommendation: Put loads in the build plane and keep the weak points of the process out of the load path.

115.7 MPa	63.6 MPa	21–29 MPa
Tensile strength along the bead, F3 PA-CF Pro	across the bead, DLR	in build direction z, DLR

01 BACKGROUND

Whether an FFF part holds is largely decided in CAD. Material and printer set the framework, but geometry and orientation determine how much of it reaches the part.

FFF builds parts bead by bead and layer by layer. This leads to rules that do not exist in injection moulding or milling:

- Strength depends on direction, especially with fibre-reinforced filaments.
- Overhangs need supports, bridges have a limiting length.
- Wall thicknesses should match the bead width of the nozzle.
- Dimensions change through shrinkage, annealing and moisture.

This paper is part of our white paper series (overview in WP001). WP002 covers moisture in the filament, WP003 the post-processing of parts. WP004 comes before that: it shows how to design parts so that they print reliably and perform in use. The rules follow the design guideline VDI 3405 Part 3.4 for material extrusion and our experience from more than 30 printers in contract manufacturing.

The following chapters proceed in the order in which the decisions are made in the design: first the direction of the loads and the orientation in the build space, then walls, overhangs and fits, and finally joints, warping and the special features of fibre-reinforced filaments.

FIG. 1: SCHEMATIC SECTION A–A . BEADS AND LAYERS

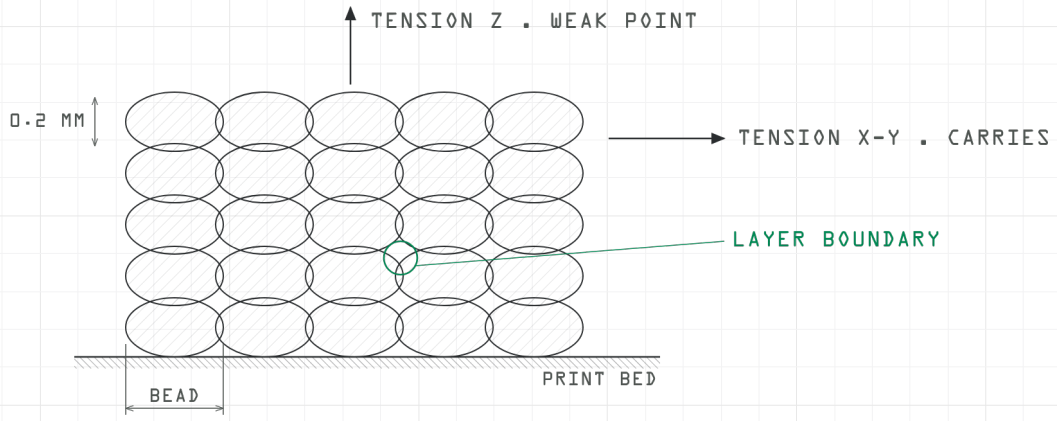


FIG. 1 Stacked beads in section with tension in x-y and z, schematic, not to scale.

02 ANISOTROPY

An FFF part is not a homogeneous material. Along the beads the material carries full load, across them and between the layers considerably less. With fibre-reinforced filaments this difference is greatest, because the fibres align along the bead during extrusion.

DLR measured the tensile strength of the Fiberthree polyamides with beads in the load direction (0°) and across it (90°). For F3 PA-CF Pro, specimens in the build direction (z) from three printers were added:

FIG. 2: ANISOTROPY

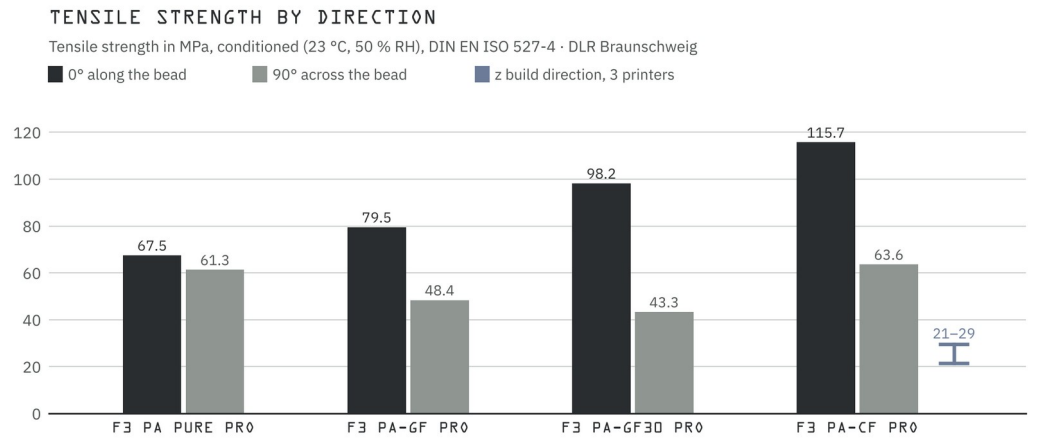


FIG. 2 DLR Braunschweig, project EmpowerAX: material characterisation of Fiberthree polyamide filaments (2023), tensile tests

For the unfilled F3 PA Pure Pro, 0° and 90° are close together. The more fibres, the more the strength rises along the bead, while across it it even drops. With F3 PA-CF Pro, the z direction carries only about a fifth of the load possible along the bead.

FIG. 3: ANISOTROPY

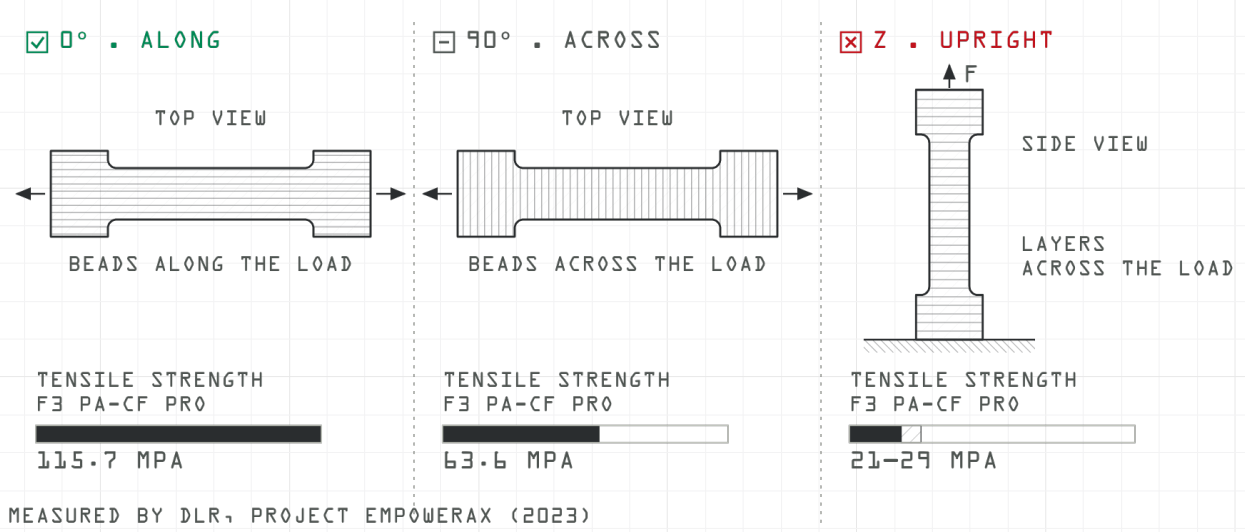


FIG. 3 Same material, three orientations: beads in the load direction carry the most, tension across the layer boundaries the least (F3 PA-CF Pro, DLR).

Stiffness behaves similarly. The modulus of F3 PA-CF Pro is 11,423 MPa along the bead and 4,829 MPa across it, and 1,813 to 2,479 MPa in z depending on the printer. Thermal expansion in z is also about five times as large as along the bead (see WP003).

The literature shows the same effect for unfilled plastics and for whole parts. Hambali et al. printed an ABS bracket in three orientations and loaded it to failure [2]. The same geometry failed at 17 kg or only at 31 to 32 kg depending on its position in the build space, i.e. at almost twice the load. The fractures show the cause: the cracks ran around the screw hole or along the layers. The modulus of the associated tensile specimens also differed by direction (1,822 to 2,228 MPa).

A simulation does not replace the test. A linear FEM calculation with direction-dependent properties matched the measured deformation for only one of the three orientations (1.65 mm calculated versus 1.80 mm measured). For another it gave 2.95 mm instead of 6.28 mm [2]. The location of failure, on the other hand, was predicted well. FEM is therefore suitable for finding critical areas; loads and deformations of an FFF part should be verified on a printed sample.

This leads to the most important design rule: put loads along the beads and avoid tension in the build direction. Chapters 03 and 09 describe how. WP009 shows how strength in the build direction can be improved through nozzle temperature and print speed.

FIG. 4: ANISOTROPY

SECTION . FORCES IN BUILD DIRECTION

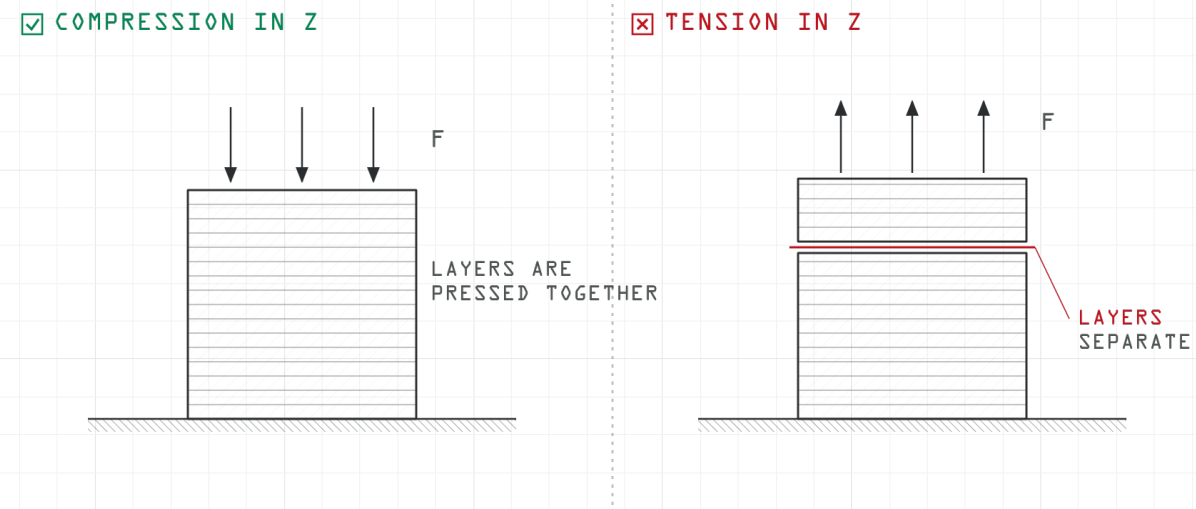


FIG. 4 Compression perpendicular to the layers is carried, tension in the build direction separates the layers.

03 PART ORIENTATION IN THE BUILD SPACE

Orientation in the build space is the first design decision, not the last setting in the slicer. It determines where the layer boundaries lie, how much support material is needed and which surfaces look good.

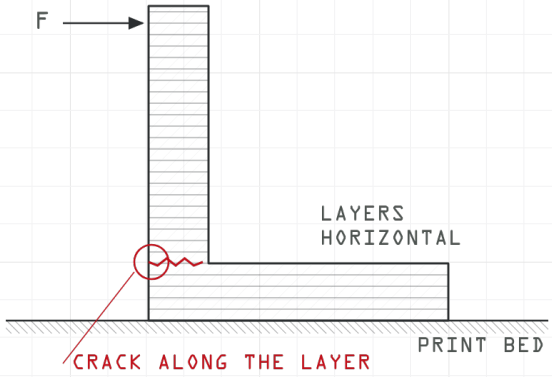
ORIENT ALONG THE LOAD PATH

- **Tension and bending in the build plane (x-y).** Main loads should run along the beads, not across the layer boundaries.
- **No notches or cross-section steps in z.** A step that lies across the build direction becomes a predetermined breaking point between two layers.
- **Screw and compressive forces may act in z.** FFF carries compression perpendicular to the layers well, tension not.
- **Consider sustained load.** Under compression, stiffness is almost independent of direction: for ABS cylinders printed at 0°, 45° and 90°, the modulus differed by only about 4 %. Under constant deformation, however, the specimen printed at an angle (45°) relaxed the most stress, after 30 minutes to an average of 19.6 MPa compared with 22.0 MPa at 90° [3]. Parts under sustained load, such as clamps or bolted flanges, should therefore not be placed at an angle in the build space.
- **Print snap fits and spring elements flat,** so that they bend in the build plane. In z a bending beam loses about half of its elongation at break.

FIG. 5: ORIENT ALONG THE LOAD PATH

VIEW . BRACKET UNDER LOAD

☒ PRINTED UPRIGHT



☑ PRINTED FLAT

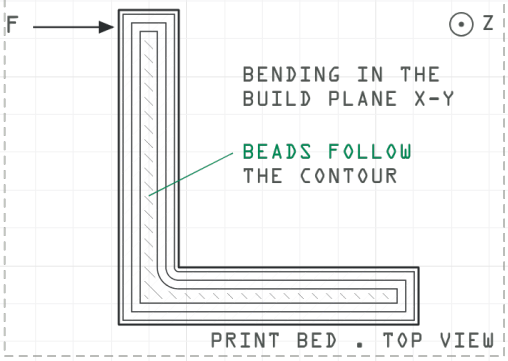
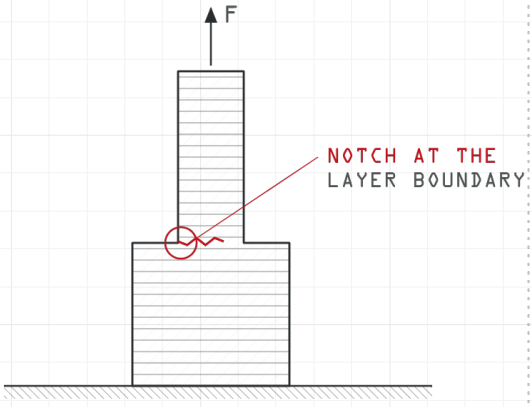


FIG. 5 The same bracket printed upright and flat: flat, it bends in the build plane; upright, it cracks at the layer boundary.

FIG. 6: ORIENT ALONG THE LOAD PATH

SECTION . CHANGE OF CROSS-SECTION

☒ STEP ACROSS Z



☑ FLAT, WITH RADIUS

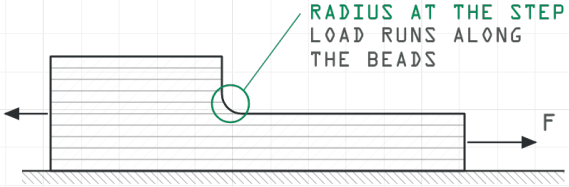


FIG. 6 A step across the build direction becomes a notch between two layers. Printed flat and with a radius, the load runs along the beads.

WEIGHING TRADE-OFFS

Not every requirement can be met with one orientation. This order of priority has proven itself for us:

01	**Strength:** main load in the build plane
02	**Dimensional accuracy:** fit holes and functional surfaces preferably perpendicular to the build plate so that they come out round and without supports
03	**Support material:** as little as possible, especially on functional surfaces
04	**Appearance:** visible surfaces facing up or sideways, never on supports
05	**Print time:** flat is usually faster than tall

FIG. 7: WEIGHING TRADE-OFFS

SECTION . ORIENTATION OF FIT BORES

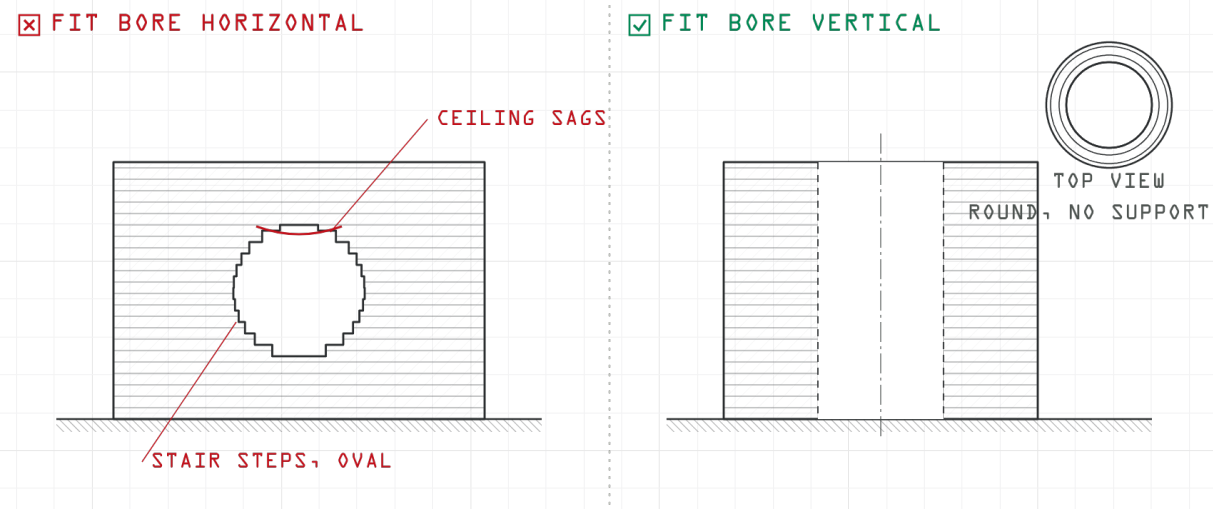


FIG. 7 Fit bores perpendicular to the build plate come out round and need no support.

If strength and geometry cannot be reconciled, splitting the part often helps. Two parts, each optimally oriented and bolted or bonded together, are often stronger than one part with poor orientation.

FIG. 8: WEIGHING TRADE-OFFS

VIEW . SPLIT INSTEAD OF SUPPORT

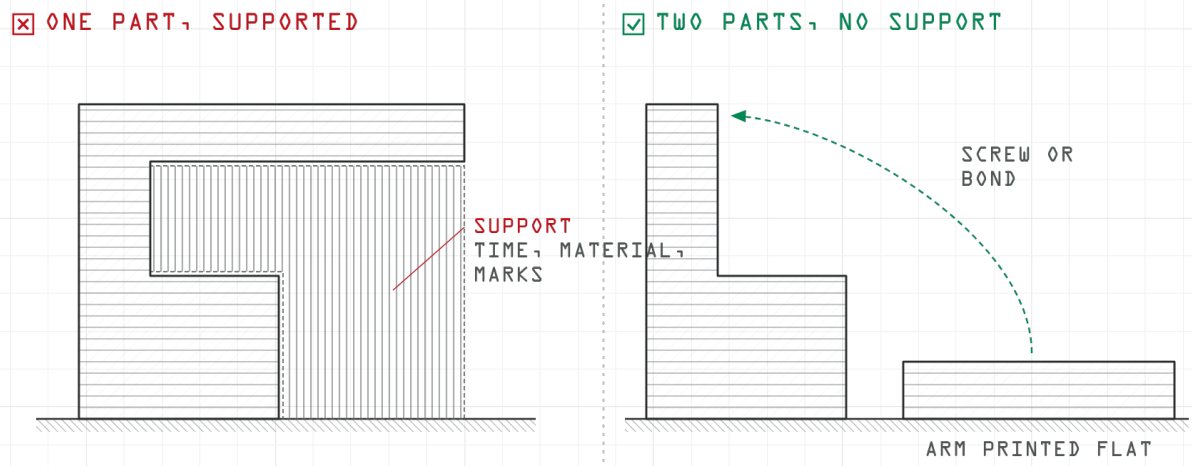


FIG. 8 Split instead of support: two parts printed flat, screwed or bonded, save support material and often carry more.

04 WALLS, PERIMETERS AND INFILL

Wall thicknesses should be an integer multiple of the bead width. Otherwise the slicer fills the gap with narrow intermediate beads or leaves it open, and that is exactly where a crack will later start.

NOZZLE	BEAD WIDTH (TYPICAL)	MINIMUM WALL	RECOMMENDED LOAD-BEARING WALL
0.4 mm	0.45 mm	0.9 mm (2 beads)	1.8 mm (4 beads)
0.6 mm	0.65 mm	1.3 mm (2 beads)	2.6 mm (4 beads)
0.8 mm	0.85 mm	1.7 mm (2 beads)	3.4 mm (4 beads)

TAB. 1 Walls, perimeters and infill.

The bead width depends on slicer and profile. The values are guide values; the slicer shows the exact bead width.

FIG. 9: WALLS, PERIMETERS AND INFILL

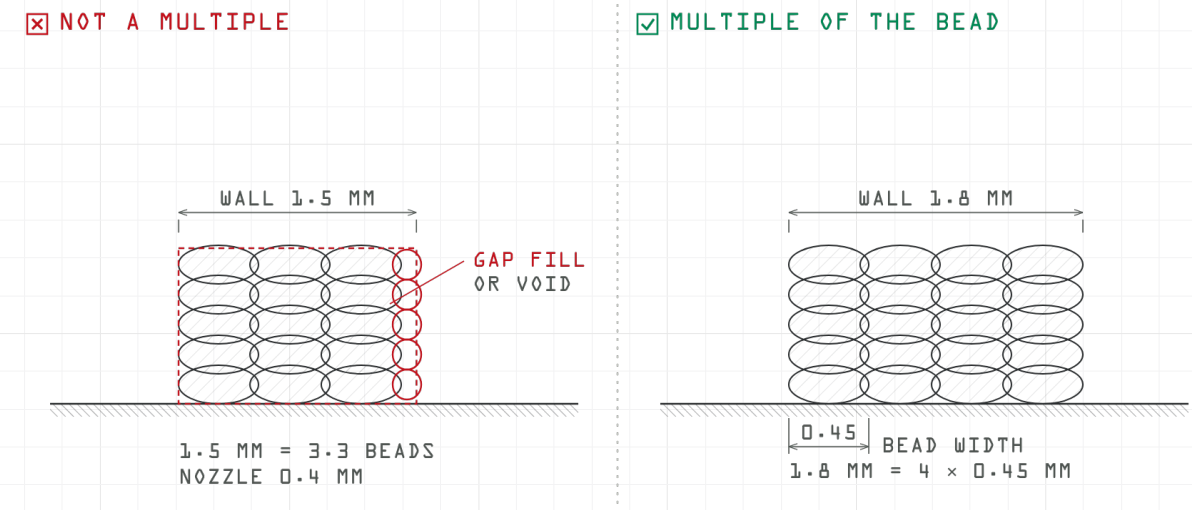


FIG. 9 Wall thickness as a multiple of the bead width: 1.8 mm gives four clean beads, 1.5 mm leaves a void or a narrow gap fill.

PERIMETERS BEFORE INFILL

The outer perimeters carry most of the bending and torsional load, because that is where most material sits at the edge of the cross-section. More perimeters therefore usually achieve more than more infill.

- **Load-bearing parts:** 4 to 6 perimeters, 30 to 50 % infill

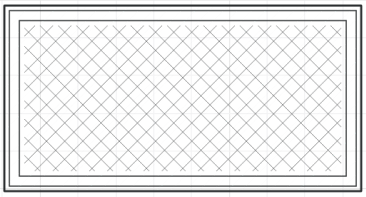
- **Parts to be annealed:** at least 3 to 5 perimeters and 50 % infill (WP003)
- **Tight parts for liquids or gases:** 100 % infill or sealing
- **Infill pattern:** gyroid or cubic distribute the load more evenly in all directions than lines

FIG. 10: PERIMETERS BEFORE INFILL

SECTION . PERIMETERS BEFORE INFILL

☐ MORE INFILL

CROSS-SECTION OF A BEAM

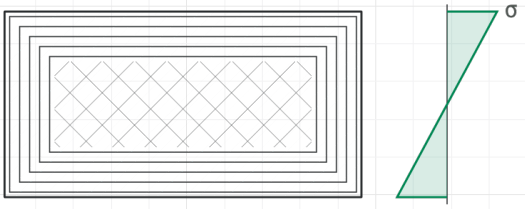


2 PERIMETERS . 50 % INFILL

INFILL SITS IN THE MIDDLE,
WHERE STRESS IS LOW

☑ MORE PERIMETERS

CROSS-SECTION OF A BEAM



5 PERIMETERS . 30 % INFILL

BENDING STRESS
PEAKS AT THE EDGE

FIG. 10 Under bending, the stress sits at the edge. More perimeters put material there, more infill only adds it in the middle.

RIBS INSTEAD OF MASS

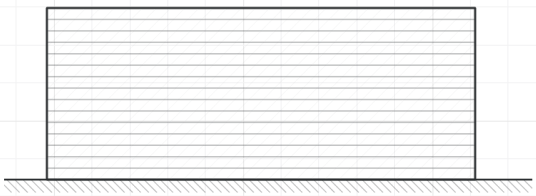
Large volumes are expensive, slow and warp in FFF. Stiffness is better achieved through geometry:

- Stiffen long, thin walls with ribs across the wall. The rib is 50 to 75 % as thick as the wall.
- Leave at least 1.5 to 2 times the wall thickness between two holes and between a hole and the edge of the part.
- Keep wall thicknesses as uniform as possible. Thick areas next to thin ones cool differently and cause warping.

FIG. 11: RIBS INSTEAD OF MASS

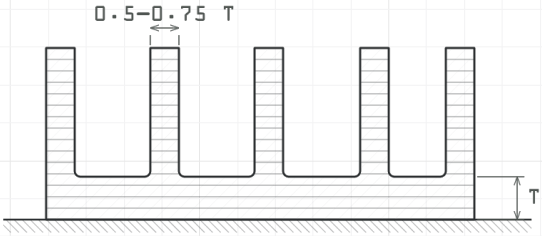
SECTION . RIBS INSTEAD OF MASS

☒ STIFFNESS FROM MASS



SOLID: LONG PRINT TIME,
MUCH MATERIAL, WARPING

☑ STIFFNESS FROM SHAPE



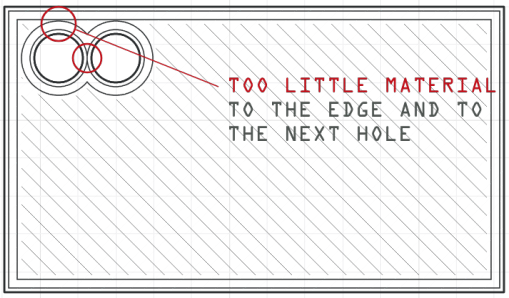
THIN WALL WITH RIBS:
SAME STIFFNESS, LESS MASS

FIG. 11 Stiffness from shape instead of mass: ribs with 50 to 75 % of the wall thickness.

FIG. 12: RIBS INSTEAD OF MASS

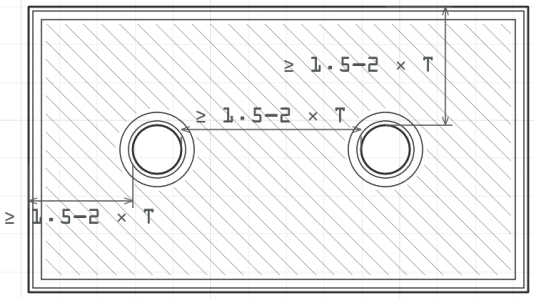
TOP VIEW . SPACING OF HOLES

☒ HOLES TOO CLOSE



TOP VIEW

☑ ENOUGH MATERIAL



TOP VIEW

T = WALL THICKNESS

FIG. 12 Leave at least 1.5 to 2 times the wall thickness between holes and to the edge of the part.

FIG. 13: RIBS INSTEAD OF MASS

SECTION . UNIFORM WALL THICKNESS

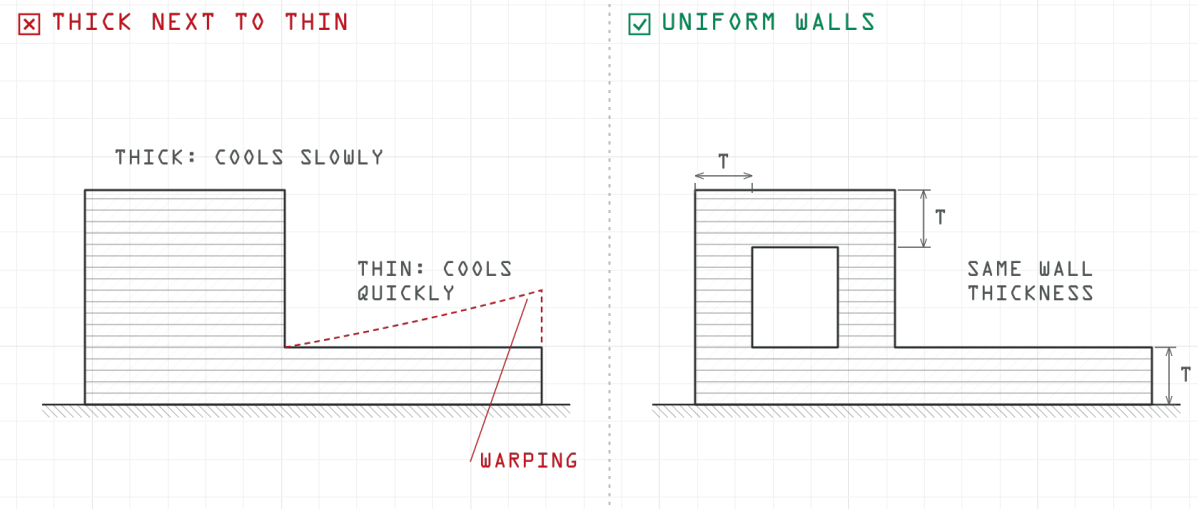


FIG. 13 Thick areas next to thin ones cool differently and warp. Uniform walls avoid this.

Infill and perimeters should therefore not be chosen across the board but according to the task of the part: for bending and torsion the outer perimeters count most, for compression and tightness a high infill. If both are needed, combine several perimeters with a medium infill and reinforce specifically the areas where forces are introduced.

A simple test helps with tuning: choose wall thicknesses in CAD so that the slicer preview shows only whole beads. Intermediate beads and gaps are easy to see in the layer preview and can usually be avoided with a change of a few tenths of a millimetre.

05 OVERHANGS, BRIDGES, SUPPORTS

Every support structure costs material and time, leaves marks on the surface and has to be removed. With polyamide this is particularly laborious because of its toughness. The best support is therefore the one designed away.

THE 45-DEGREE RULE

A wall inclined at least 45° to the build plate supports itself: each new layer still rests halfway on the previous one. Flatter overhangs need supports or a different geometry.

FIG. 14: THE 45-DEGREE RULE

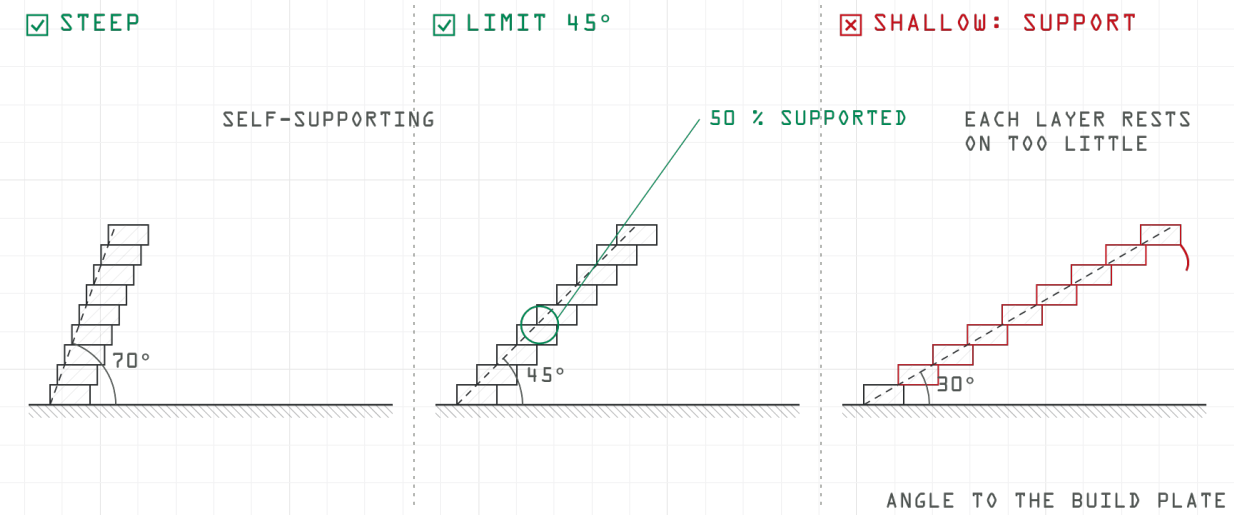


FIG. 14 At 45°, each layer still rests halfway on the previous one. Shallower walls need supports.

- **Chamfers instead of radii on lower edges.** A 45° chamfer prints cleanly, a radius runs out flat at the bottom and sags.
- **Radii on upper edges and vertical edges** are no problem and reduce stress peaks.
- **Fix just below the limit:** a surface at 40° to the build plate needs supports, at 46° often not.

FIG. 15: THE 45-DEGREE RULE

SECTION . CHAMFER OR RADIUS AT EDGES

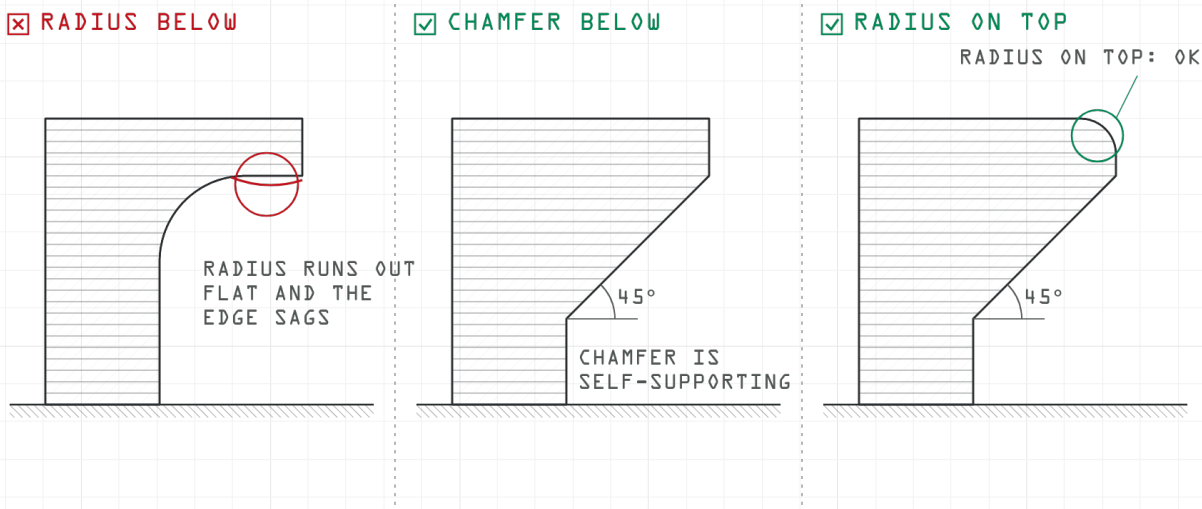


FIG. 15 On lower edges a 45° chamfer supports itself, a radius runs out flat. On upper edges radii are no problem.

HORIZONTAL HOLES

A round hole whose axis is parallel to the build plate has a flat ceiling at the top that sags. Remedies:

- **Teardrop shape:** let the hole run out to a point at 45° at the top. It then prints without support, at almost any diameter.
- **Diamond shape** for channels, with rounded corners against notch effects.
- **Fit holes** preferably perpendicular to the build plate or drilled afterwards (Chapter 06).

FIG. 16: HORIZONTAL HOLES

SECTION . HORIZONTAL HOLES

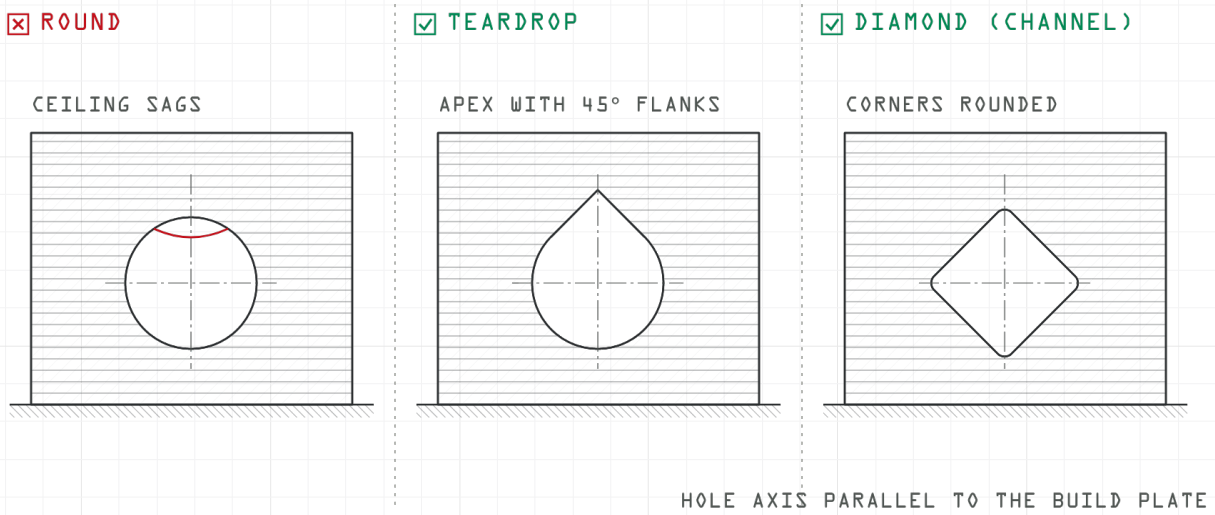


FIG. 16 Horizontal holes: round, the ceiling sags; teardrop and diamond shapes print without support.

BRIDGES

A bead can span freely between two support points. Up to about 5 mm this works reliably, with well-tuned cooling even more. Polyamide is printed with little fan and therefore sags more than PLA on long bridges. Design long spans as arches or split them into short sections.

FIG. 17: BRIDGES

SECTION . BRIDGES

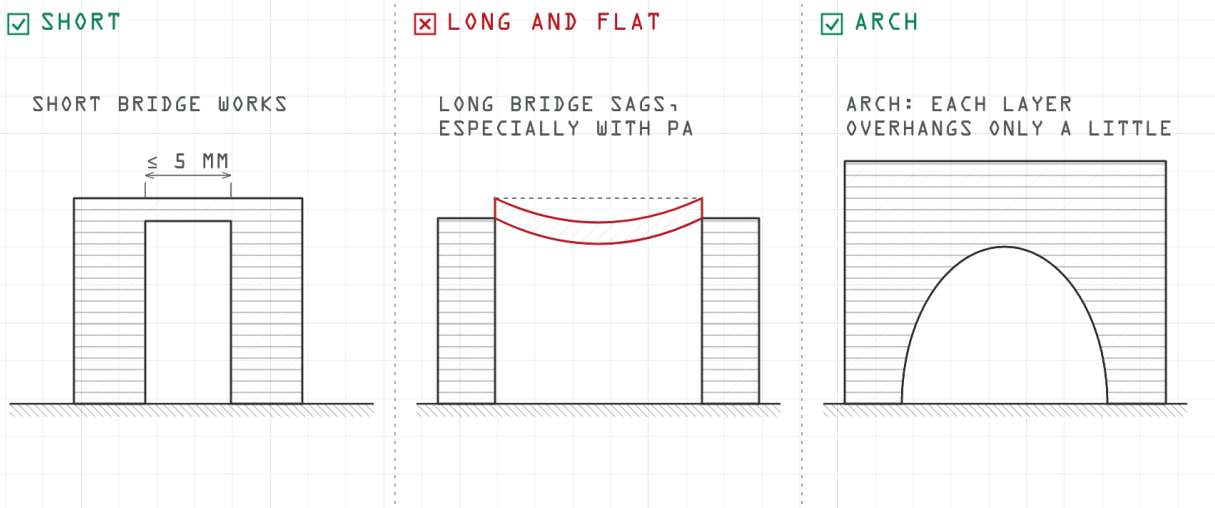


FIG. 17 Short bridges up to about 5 mm work reliably. Long spans sag; an arch avoids this.

WHEN SUPPORTS ARE NEEDED

- Place supports on surfaces that are neither functional nor visible.
- Set a defined gap between support and part in the slicer so that the support can be removed.
- For parts that will be annealed, remove supports only after annealing (WP003).

FIG. 18: WHEN SUPPORTS ARE NEEDED

SECTION . SUPPORT STRUCTURES

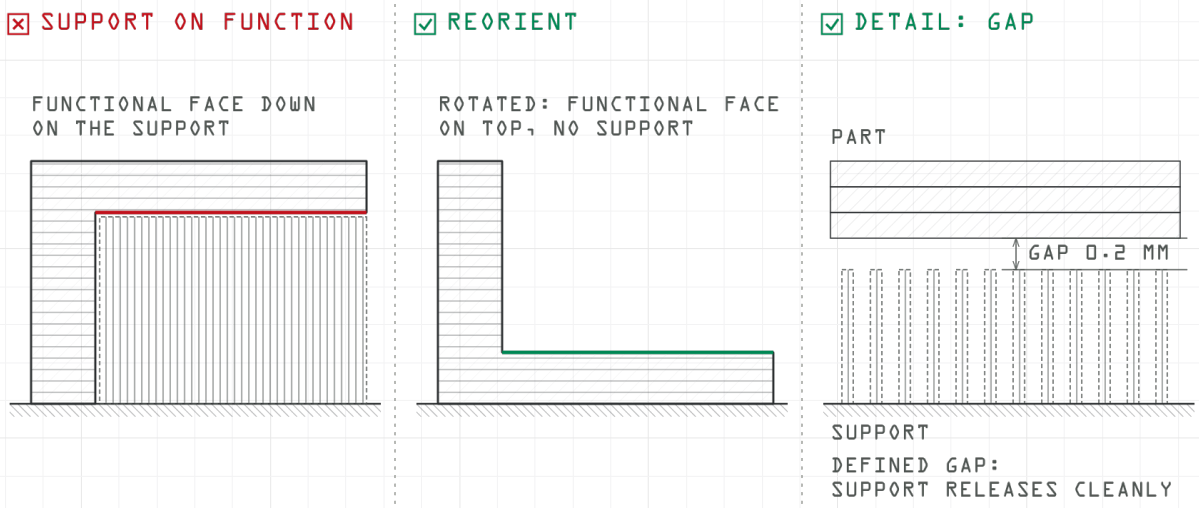


FIG. 18 Supports belong on secondary surfaces; better still, rotate the functional surface. A defined gap makes sure the support releases.

Many supports can be avoided already in the design if overhangs are shaped deliberately: chamfers instead of radii on lower edges, teardrop shapes for horizontal holes and short bridges. What remains is supported specifically, where it does not interfere with function and appearance.

With polyamide this effort is particularly worthwhile, because supports made of tough material are hard to remove and leave marks.

06 HOLES, FITS, TOLERANCES

FFF parts typically deviate from the nominal dimension by a few tenths of a millimetre. Holes usually come out too small, outer dimensions rather too large, because the bead lies slightly wider than in the model.

FIG. 19: HOLES, FITS, TOLERANCES

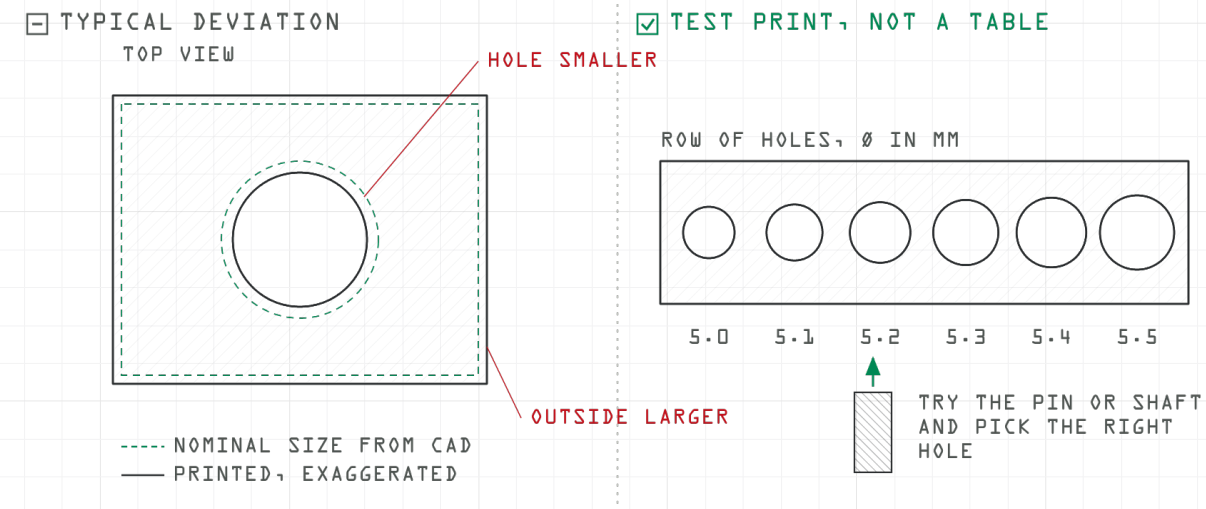


FIG. 19 Holes usually come out smaller and outer dimensions larger than in CAD. A row of holes as a test print shows the right clearance.

ALLOWING CLEARANCE

These guide values apply to a 0.4 mm nozzle and a calibrated system. They refer to the diameter:

FIT	CLEARANCE IN CAD	EXAMPLE
Press fit	0 to +0.1 mm	pins, bearing seats
Sliding fit	+0.2 to +0.3 mm	lids, guides
Clearance fit	+0.3 to +0.5 mm	shafts, through holes
Moving parts in one print	min. 0.3 mm	hinges, joints

TAB. 2 Allowing clearance.

The exact value depends on material, printer and length of the fit. A short test print with a row of holes clarifies it faster than any table.

FIG. 20: ALLOWING CLEARANCE

SECTION . ALLOW FOR CLEARANCE

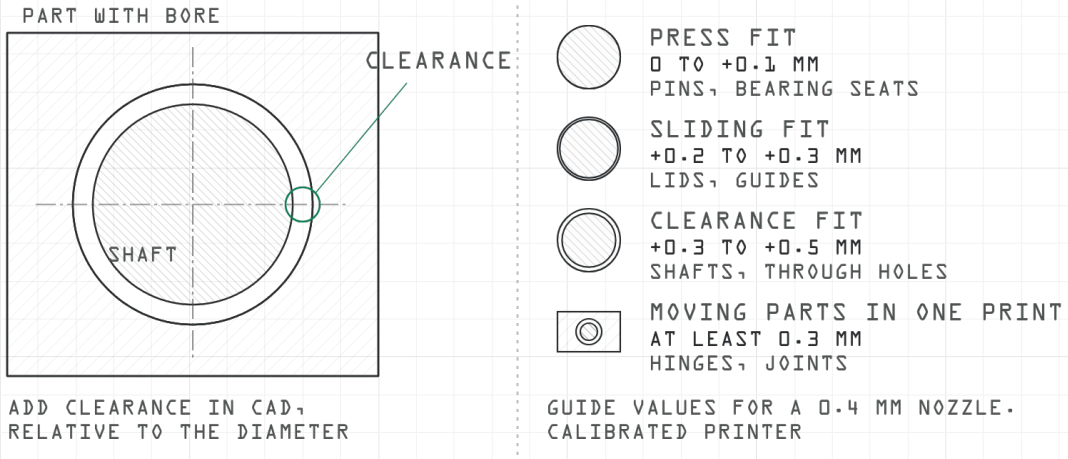


FIG. 20 Allow for clearance in CAD: guide values for a 0.4 mm nozzle, relative to the diameter.

FINISHING PRECISE DIMENSIONS

Anything that must be toleranced tighter than about ± 0.2 mm is better finished afterwards:

- Print fit holes 0.2 to 0.3 mm smaller and ream or drill them to size.
- Print sealing surfaces with allowance and mill or grind them flat.
- Use carbide tools for fibre-reinforced filaments (WP003).

FIG. 21: FINISHING PRECISE DIMENSIONS

SECTION . FINISH PRECISE DIMENSIONS

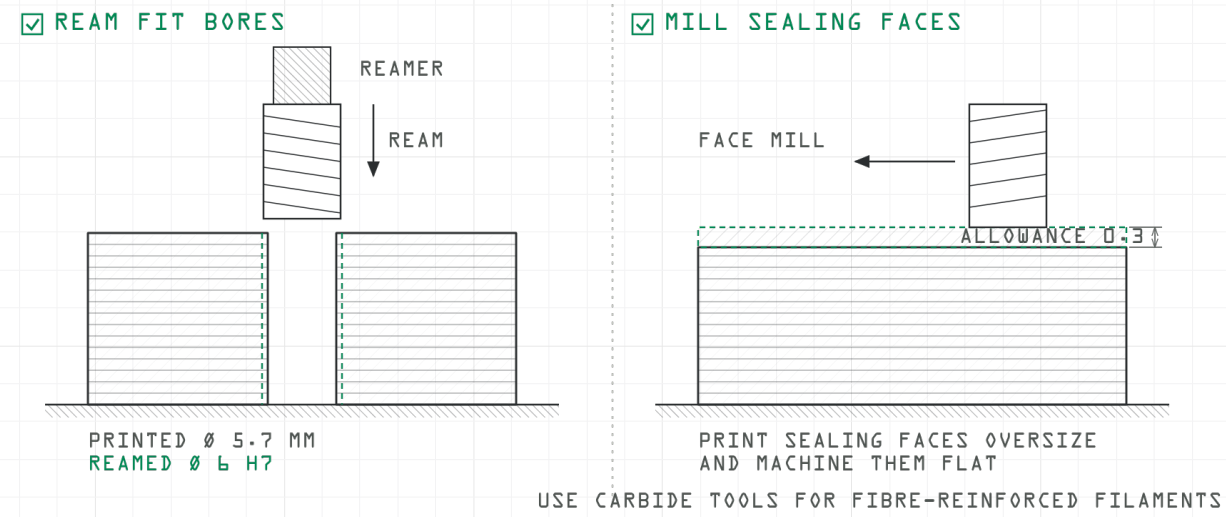


FIG. 21 Anything toleranced tighter than about ± 0.2 mm is printed under- or oversize and finished afterwards.

FIRST LAYER

The first layers are squashed slightly during printing so that they adhere well to the build plate. This bulge, often called elephant's foot, makes edges on the build plate wider than in CAD. Where they must be dimensionally accurate, a small chamfer of about 0.5 mm × 45° at the bottom edge helps.

FIG. 22: FIRST LAYER

SECTION . FIRST LAYER

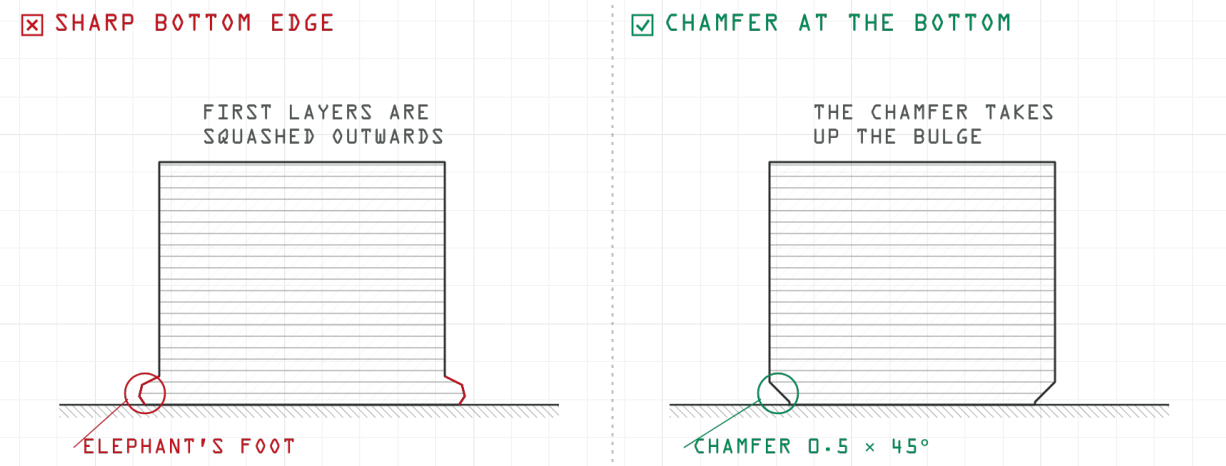


FIG. 22 The first layers are squashed outwards. A small chamfer at the bottom edge takes up the bulge.

DIMENSIONS CHANGE AFTER PRINTING

A part does not yet have its final dimensions after printing:

- **Annealing** makes polyamide shrink, strongly depending on direction (WP003). Measure the shrinkage on a test specimen and allow for it in CAD.
- **Moisture uptake** makes polyamide swell. Check fits in the state in which the part is used.
- **Thermal expansion** of F3 PA-CF Pro is about five times as large in the build direction as along the bead (DLR). Place critical fits in the build plane.

FIG. 23: DIMENSIONS CHANGE AFTER PRINTING

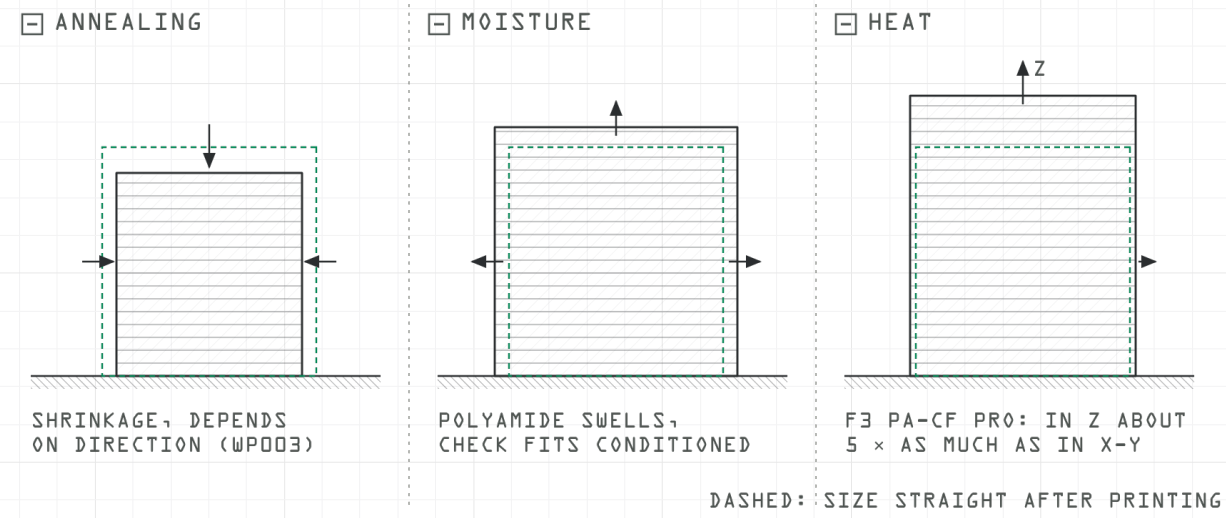


FIG. 23 After printing, annealing, moisture and heat change the dimensions. Check critical fits in the condition of use.

A test print with a row of holes and pins in the planned dimensions is the fastest way to reliable fits. It shows how much clearance is actually needed for the material, printer and profile, and can be reused for later projects.

If the part is annealed or used in a moist state, the test specimen should go the same way. Only then do the measured values show what to expect in use.

07 JOINTS

The joint is often the weakest point in FFF assemblies. Which joint fits depends on how often it is released and what load it carries.

JOINT	SUITABLE FOR	ASSEMBLY CYCLES
Threaded insert (brass)	load-bearing, frequently released screw joints	many
Thread directly in the plastic	rarely released joints, small forces	few
Nut in pocket	high forces, simple and cheap	many
Snap fit	lids, housings, tool-free assembly	depending on design
Bonding	permanent connection of sub-parts	once

TAB. 3 Joints.

THREADED INSERTS AND SCREW BOSSES

- Hole as specified by the insert manufacturer, with a small chamfer as an insertion aid.
- 4 to 6 perimeters around the hole so that the insert sits in solid material.
- Screw bosses at least twice as thick as the outer diameter of the insert, rounded at the base and tied to the wall with ribs.
- Place the hole axis in the build direction if possible. The pull-out force then runs over many perimeters instead of over one layer boundary.
- Heat-set only after annealing (WP003).

FIG. 24: THREADED INSERTS AND SCREW BOSSES

SECTION . BOSS WITH THREADED INSERT

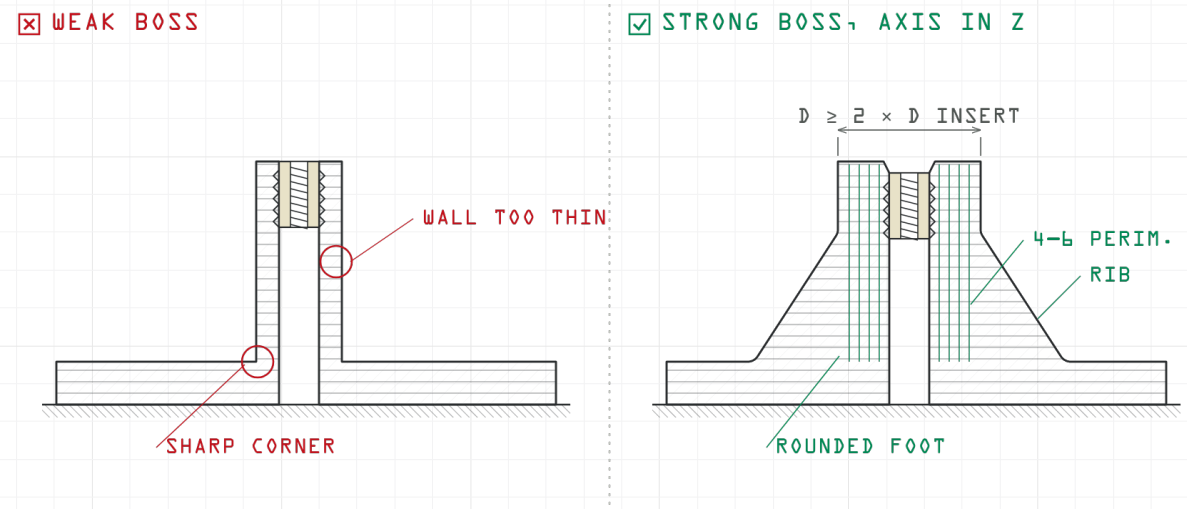


FIG. 24 A load-bearing screw boss: at least twice the insert diameter, many perimeters, a rounded base and ribs to the wall.

NUTS IN POCKETS

Hexagonal pockets can be printed without supports if the nuts are inserted from above. A short print pause at the right layer height encloses the nut completely. This is the cheapest solution for high forces.

FIG. 25: NUTS IN POCKETS

SECTION . CAPTIVE NUT

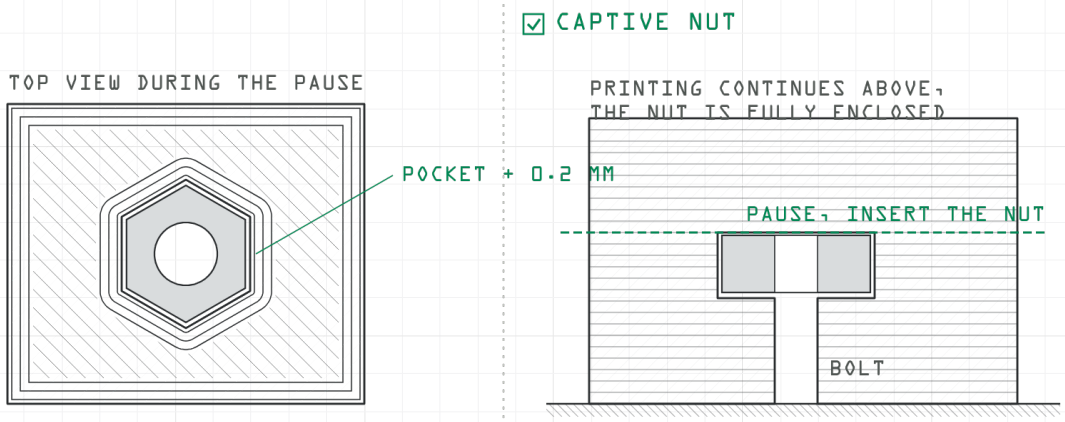


FIG. 25 Captive nut: pause at the right layer height, insert the nut, continue printing.

SNAP FITS

Polyamide is well suited for snap fits because it is tough and tolerates a lot of strain.

- **Print flat,** so that the hook bends in the build plane (Chapter 03). In z the permissible strain should be halved.
- **Round the base,** at least 1 mm. Sharp corners at the base are the most common point of failure.
- **Taper the design:** a hook that becomes thinner towards the tip distributes the strain more evenly.
- **Clearance:** about 0.5 mm to the mating part.
- **Fibre-reinforced grades** are stiffer and stretch less. For snap fits, unfilled F3 PA Pure Pro or F3 PA Pure Lite is the better choice.
- **Condition** before first assembly, because dry polyamide is more brittle (WP003).

FIG. 26: SNAP FITS

VIEW . SNAP-FIT HOOK

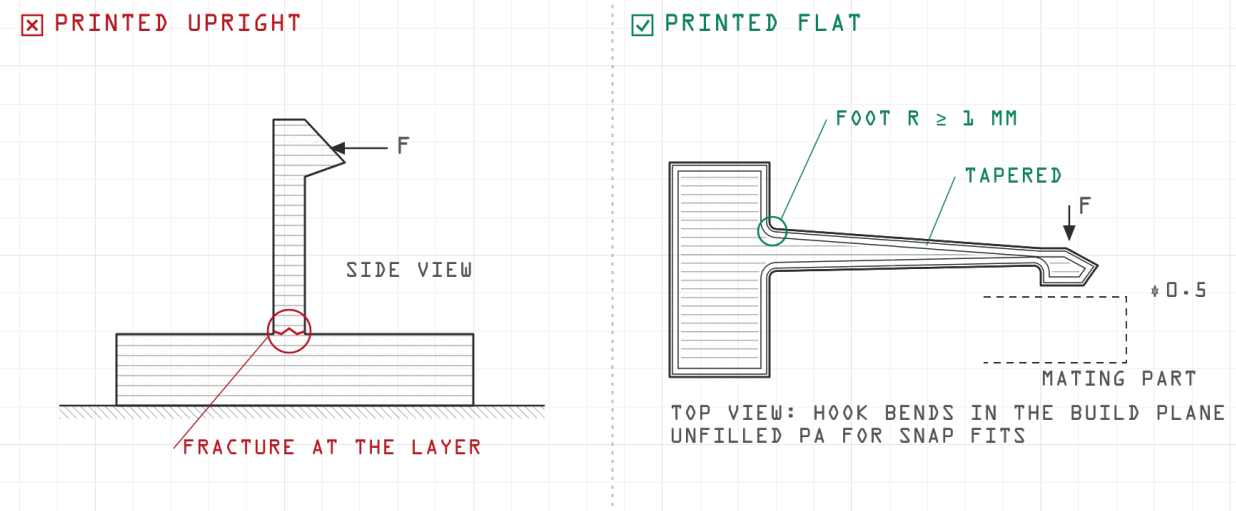


FIG. 26 Print snap fits flat so that they bend in the build plane; taper them, round the base and leave clearance to the mating part.

The choice of joint should be made early, because it determines the geometry around the joint: threaded inserts need material and perimeters, nuts a pocket and a print pause, snap fits an orientation in the build plane.

08 AVOIDING WARPING

Warping occurs because each new layer shrinks on cooling and pulls on the layer below. The forces add up over the length of the part and lift corners off the print bed. Semi-crystalline plastics such as polyamide shrink more than amorphous ones.

FIG. 27: AVOIDING WARPING

SECTION . HOW WARPING HAPPENS

THE PULLING FORCES ADD UP OVER THE LENGTH OF THE PART
AND LIFT THE CORNERS FROM THE BED. POLYAMIDE SHRINKS
MORE THAN AMORPHOUS PLASTICS, AS IT IS SEMI-CRYSTALLINE.

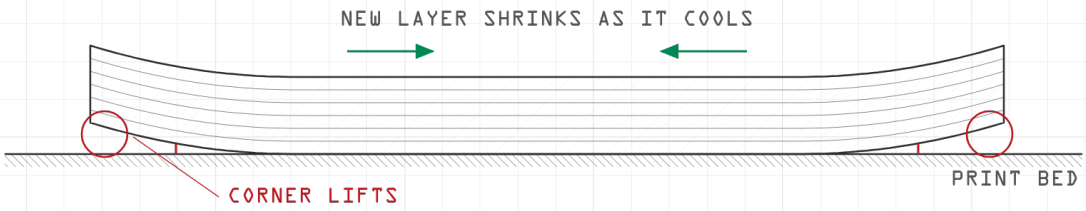


FIG. 27 How warping happens: each new layer shrinks as it cools; the forces add up and lift the corners from the bed.

COUNTERING IT BY DESIGN

- **Round corners.** Shrinkage forces concentrate in sharp corners. Even radii of 3 to 5 mm in the footprint help considerably.
- **Avoid large flat surfaces on the print bed** or interrupt them with grooves and cut-outs.
- **Uniform wall thicknesses.** Thick areas cool more slowly and pull thin ones along.
- **Long, slender parts:** place them diagonally in the build space or split them.
- **Mouse ears at the corners:** small, thin discs at the corners of the first layer increase the contact area and are cut off after printing.

FIG. 28: COUNTERING IT BY DESIGN

TOP VIEW . FOOTPRINT AGAINST WARPING

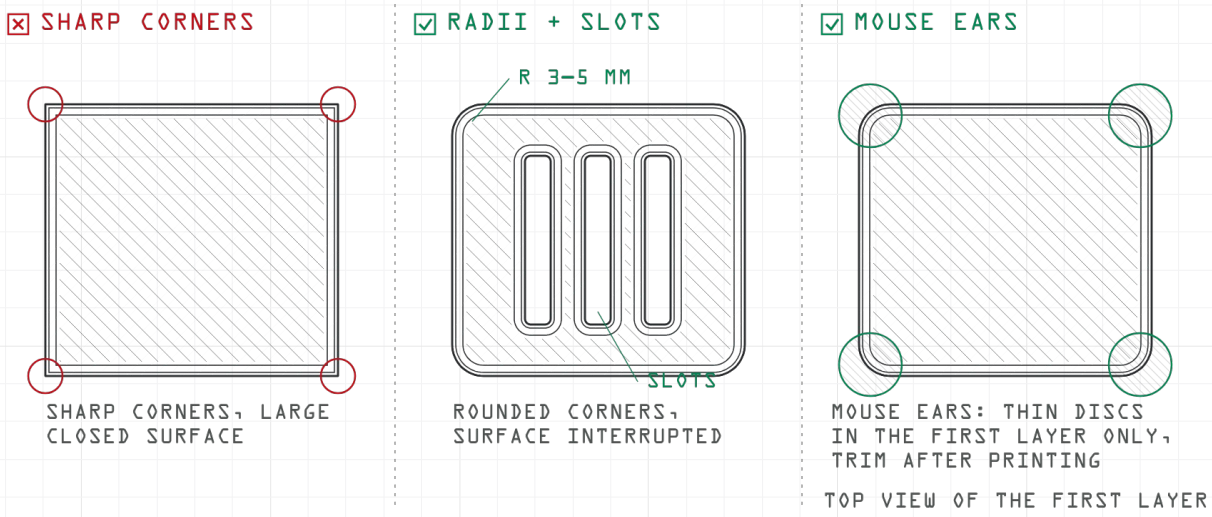


FIG. 28 Against warping in the footprint: round the corners, interrupt large surfaces, add mouse ears at the corners.

FIG. 29: COUNTERING IT BY DESIGN

TOP VIEW . LONG PARTS ON THE PLATE

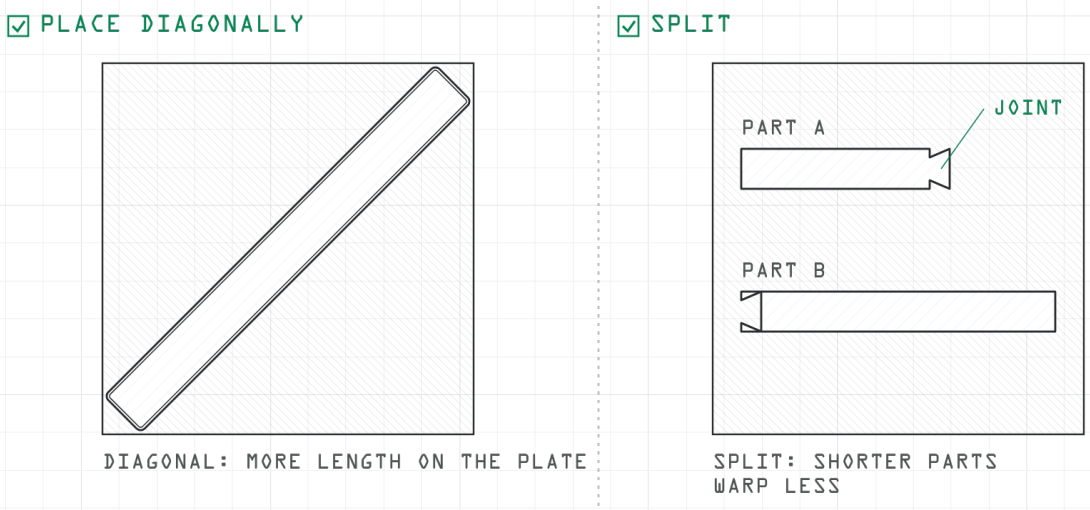


FIG. 29 Place long, slender parts diagonally on the build plate or split them.

MATERIAL AND PROCESS

- **Choose fibre-reinforced filaments** where the application allows. The fibres hinder shrinkage along the bead. According to its data sheet, F3 PA-CF Pro shows very low warping.
- **Print bed with good adhesion:** for polyamide, carbon build plates such as those offered by Fiberthree are suitable.

- **A closed, warm build chamber** reduces the temperature difference between fresh and cold layers.
- **Dry filament.** Moist polyamide prints with bubbles and poorer layer adhesion, which promotes warping and cracks (WP002).

09 FIBRE-REINFORCED FILAMENTS

With fibres, the bead path in the slicer becomes a design tool. The fibres align along the bead during extrusion. Where the beads run, the strength goes (Chapter 02).

ROUTING BEADS ALONG THE LOAD

- **Perimeters follow the contour.** For parts with loads along the outer shape, additional perimeters carry more than infill because their fibres lie in the load direction.
- **Align the infill angle.** For flat, elongated parts, set the infill angle in the direction of the main load.
- **Enclose holes.** Perimeters around holes route the load around the hole like a fibre ring.

FIG. 30: ROUTING BEADS ALONG THE LOAD

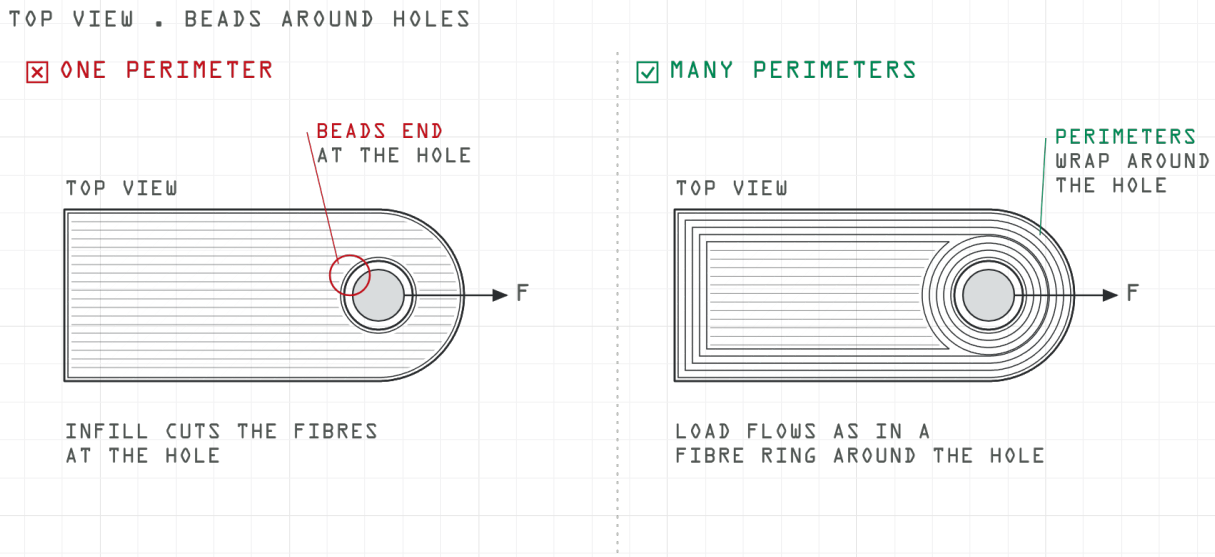


FIG. 30 With fibres, what the beads enclose carries the load: perimeters around a hole route the load like a fibre ring.

FIG. 31: ROUTING BEADS ALONG THE LOAD

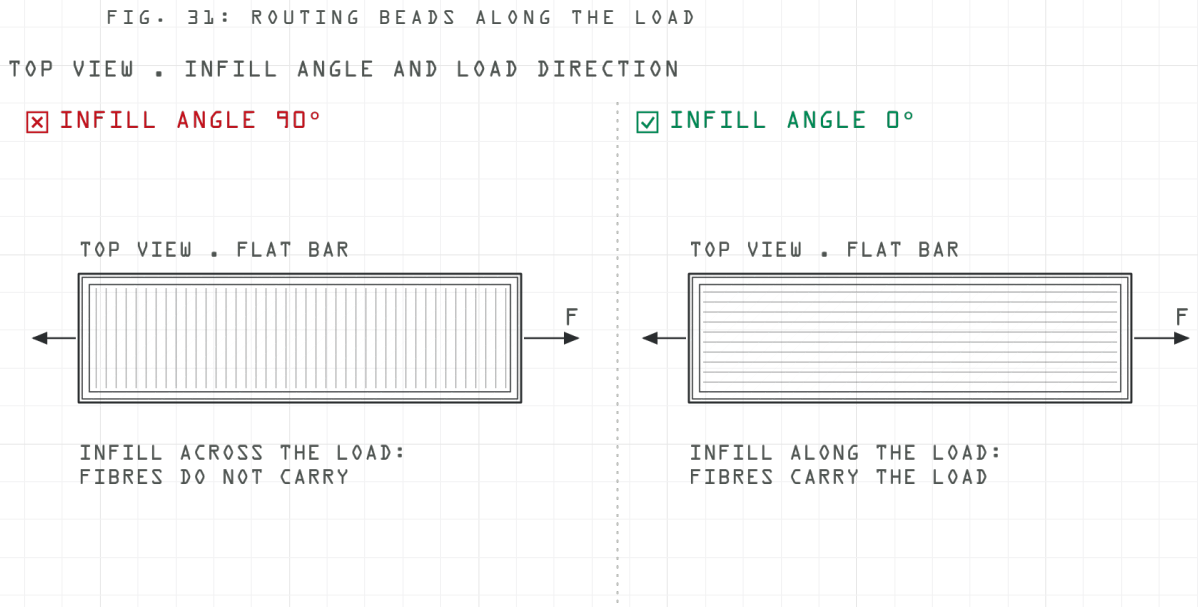


FIG. 31 For flat parts, set the infill angle in the direction of the main load.

NOZZLE AND DETAIL SIZE

- **Wear-resistant nozzle:** carbon and glass fibres quickly wear out brass nozzles. Hardened steel is the minimum, tungsten carbide or ruby last longer.
- **Diameter:** the data sheet of F3 PA-CF Pro specifies more than 0.25 mm. For functional parts we recommend 0.4 to 0.6 mm. The test specimens in the data sheet of F3 PA-GF30 Pro were printed with 0.6 mm.
- **Smallest details:** wall thicknesses and ribs not below two bead widths, lettering and engravings not finer than the nozzle.
- **Layer height:** choose it rather larger. Thicker layers improve flow and layer adhesion of fibre-reinforced melts.

FIG. 32: NOZZLE AND DETAIL SIZE

SECTION . SMALLEST FEATURES

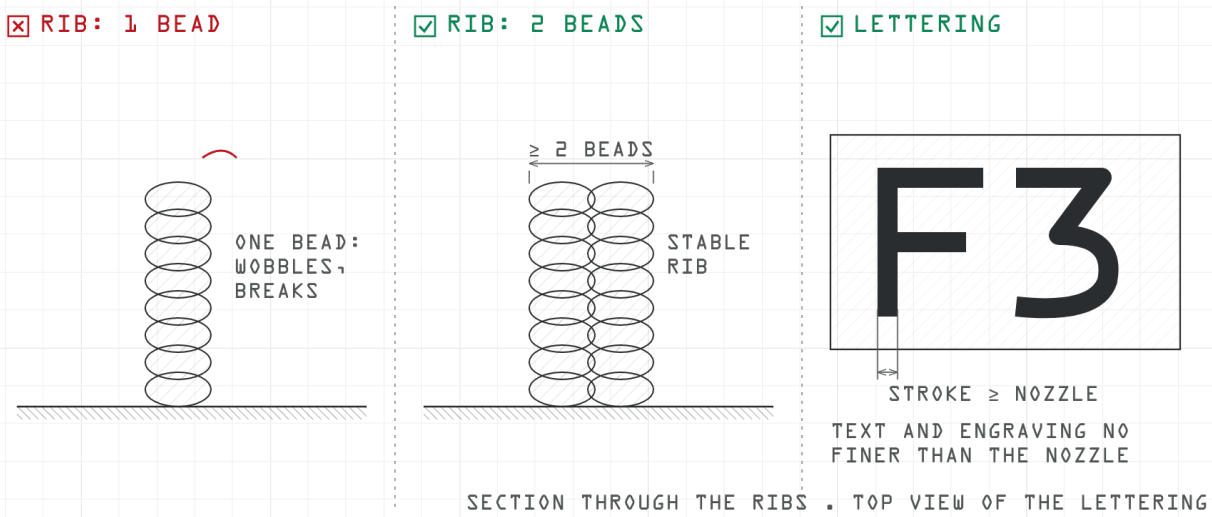


FIG. 32 Ribs not below two bead widths, lettering and engravings not finer than the nozzle.

CHOOSING THE MATERIAL FOR THE TASK

REQUIREMENT	RECOMMENDATION
Maximum stiffness and strength	F3 PA-CF Pro
High compressive strength, cost-effective	F3 PA-GF30 Pro
Toughness, snap fits, hinges	F3 PA Pure Pro, F3 PA Pure Lite
Low moisture uptake, dimensional stability	F3 PA-CF Lite (PA12)
Electrostatic dissipative	F3 PA ESD
No water uptake, chemically resistant	F3 PP GF 25

TAB. 4 Choosing the material for the task.

With fibre-reinforced filaments the bead path is part of the design. It is worth checking the beads in the slicer preview and adjusting them specifically instead of taking over the default settings. Additional perimeters or an adjusted infill angle often achieve more than a stiffer material.

For details the nozzle is the limit: anything finer than two bead widths cannot be reproduced cleanly with filled filaments.

10 DESIGN CHECKLIST

Before release for printing:

01	The main load lies in the build plane, no tension across layer boundaries
02	Notches and cross-section steps do not lie across the build direction
03	Wall thicknesses are a multiple of the bead width, load-bearing walls at least 4 beads
04	Surfaces are inclined at least 45° to the build plate or deliberately supported
05	Lower edges have chamfers instead of radii, horizontal holes a teardrop shape
06	Fits have clearance according to the table, tight dimensions are finished afterwards
07	Shrinkage from annealing is allowed for (WP003)
08	Threaded inserts have enough material and perimeters
09	Snap fits lie in the build plane, with a rounded base
10	Corners in the footprint are rounded, large surfaces interrupted
11	Material and nozzle suit the task
12	Filament is dried (WP002)

If you are unsure whether a part can be printed like this: our engineering team adapts CAD data to the FFF process and checks feasibility.

11 CONCLUSION

How strong an FFF part is, is largely decided in CAD. Placing the main load in the build plane, matching walls to the bead width, designing out overhangs and allowing for dimensional changes from annealing and moisture gives parts that print reliably. The checklist in Chapter 10 sums up the rules for release.

If a part cannot be classified clearly, a test print in the planned orientation helps. It shows faster than any calculation whether orientation, wall thicknesses and fits work together.

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ABOUT FIBERTHREE

Fiberthree develops and produces technical filaments for FFF printing in Darmstadt, with polyamide at the heart of the portfolio. Building on our background as an engineering office, we also offer engineering, training and contract manufacturing on more than 30 printers, from first sample to small series. This includes CAD adaptations for FFF, slicer settings and recommendations on fibre reinforcement and post-processing.

WHITE PAPER SERIES

All white papers are available at www.fiberthree.com. We update the series regularly; the latest version applies.

NO.	TOPIC	HELPS WITH
WP001	Plastics for the FFF Process: Material Overview and Process Comparison	Choosing material and process
WP002	Effect of Moisture on Polymers in the FFF Process	Drying filament and keeping it dry
WP003	Annealing and Post-Processing of FFF Parts	Annealing, conditioning, finishing
WP004	**Design for Manufacturing in the FFF Process (this paper)**	**Designing parts for FFF**
WP005	Heat-Setting Threaded Inserts in FFF Parts	Detachable screw connections
WP006	Nozzle Selection for Filled Filaments	Nozzle material and diameter
WP007	Print Bed and Adhesion	First-layer adhesion
WP008	Electrostatic Dissipative (ESD) Parts in FFF Printing	Printing and testing ESD parts
WP009	Interlayer Adhesion in the Build Direction: Nozzle Temperature, Print Speed and Hotend	Strength in the z direction

TAB. 5 Overview of the Fiberthree white papers.

FIBERTHREE

START WITH THE RIGHT MATERIAL

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