Science and Technology Facilities Council

Additive Manufacturing Facility
Building R9
Email: sam.allum@stfc.ac.uk
dave.wilsher@stfc.ac.uk
Phone: 01235 445472

Manufacturing Facilities Group - Additive Manufacturing Facility

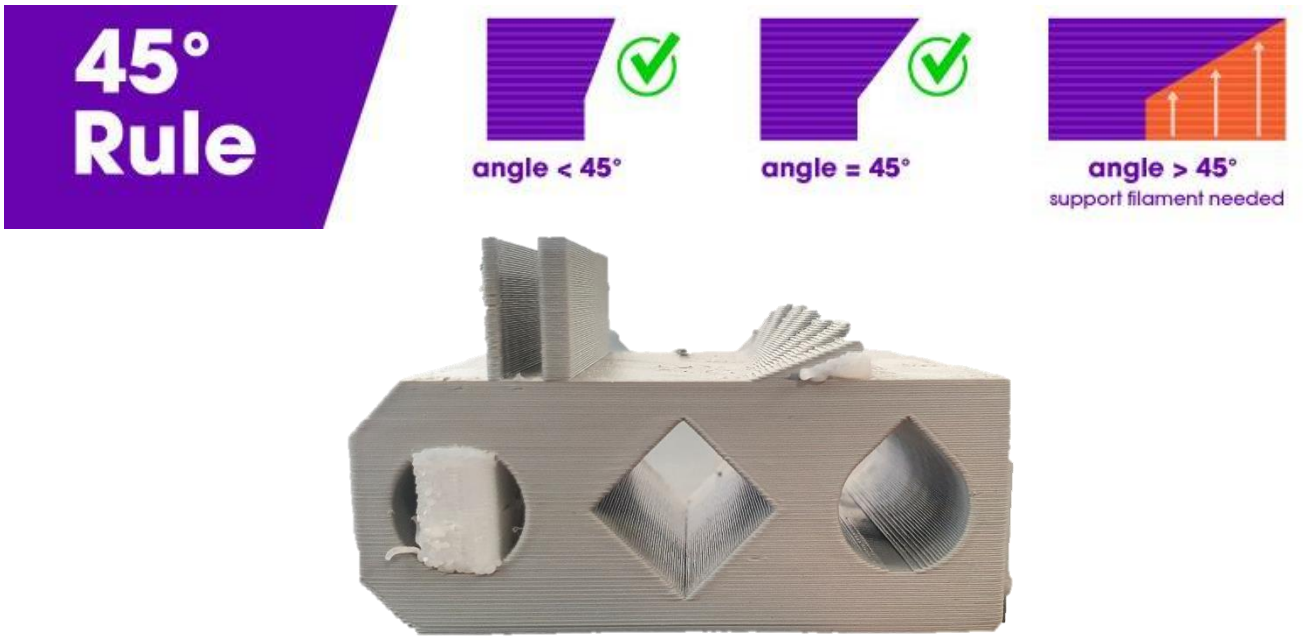
Design Tips

Overhang and holes:

When 3D printing, an overhang is where parts of the print aren't supported by the print surface or the previous layer of printed material. When the overhang is greater than 45 degrees (see below), support is used to fill the gaps so the model doesn't collapse into itself.

Using support material increases both the cost and the time needed to print the model. It also increases the amount of manual finishing time needed after the part has been printed as the support has to be removed.

A good way to remove support material is at the design stage by using the 45º rule and turning circular holes into 'teardrop' or 'diamond' shapes as shown below. This only applies to non-threaded holes printed in the XY build plane. We are happy to advise further if you're not sure.



Threaded Holes:

If your design requires a hole to be threaded, tapping 3d printed parts can produce weak threads. Alternatively you can use a nut glued into place or using a brass insert, both of which the facility can supply. Below is a table of the sizes of the brass inserts we have in stock. It also shows the size of the hole needed to allow fitment. If a nut is used the hexagonal feature can be made self-supporting as described above.

Insert	Straight	Lipped
M3	4.3Ø x 5	4.3Ø x 4.5 lip 5.6 x 0.6
M4	5.9Ø x 8	5.9Ø x 7.1 lip 7.2Ø x 1
M5	6.5Ø x 9.5	6.7Ø x 8.5 lip 8Ø x 1.1
M6	N/A	8.2Ø x 11.4 lip 9.6Ø x 1.3
All Dims in mm		

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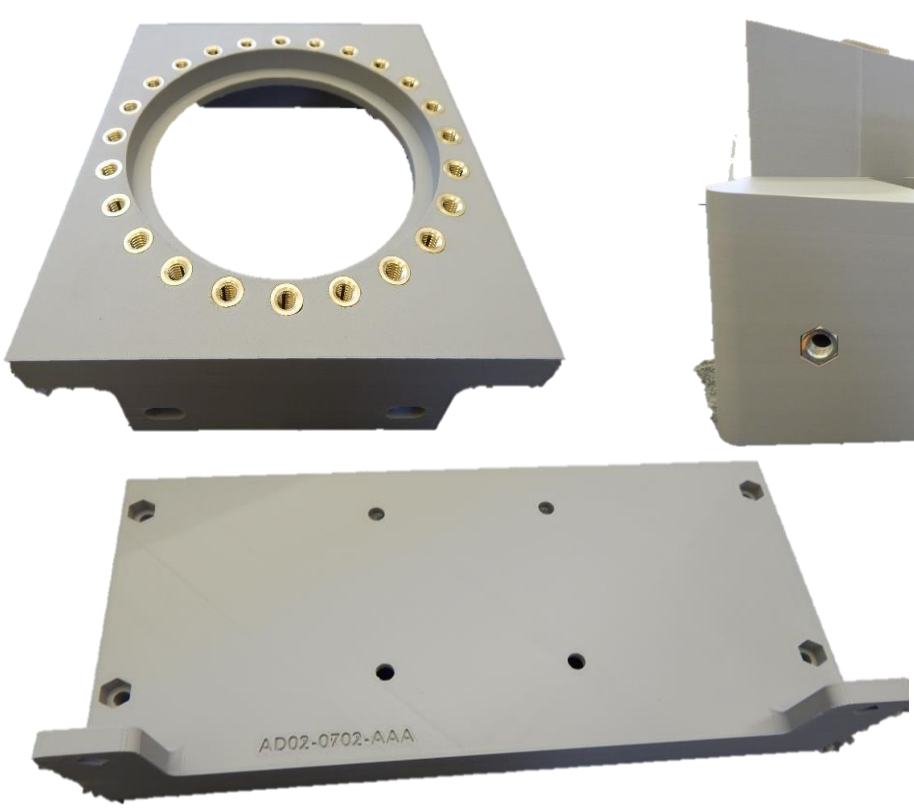
Examples of threaded inserts:



Using Text on Parts:

When adding text to your parts, generally the smallest text that will print successfully is 3mm high characters. It's much clearer to inset the text rather than having protruding characters. When insetting the text on your part use a depth of at least 1.5 mm. When choosing a typeface, choose one that has adequate spacing between the letters.

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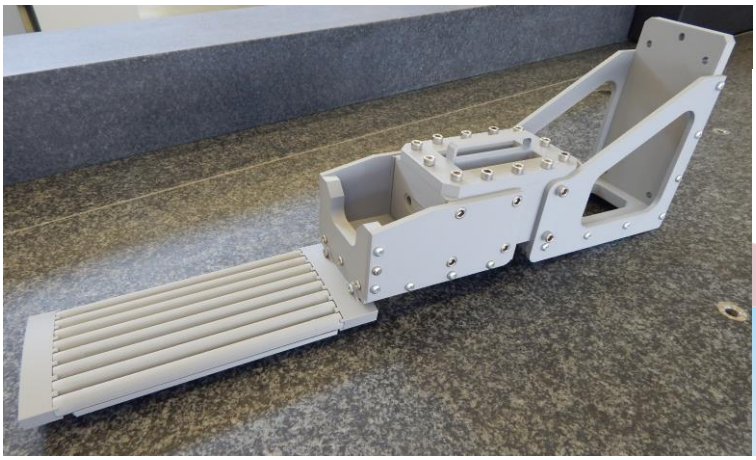
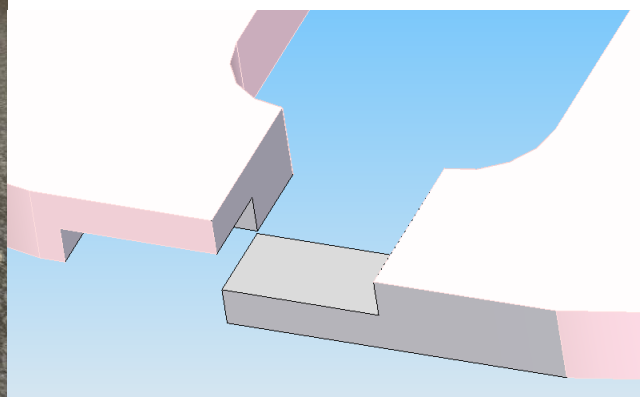
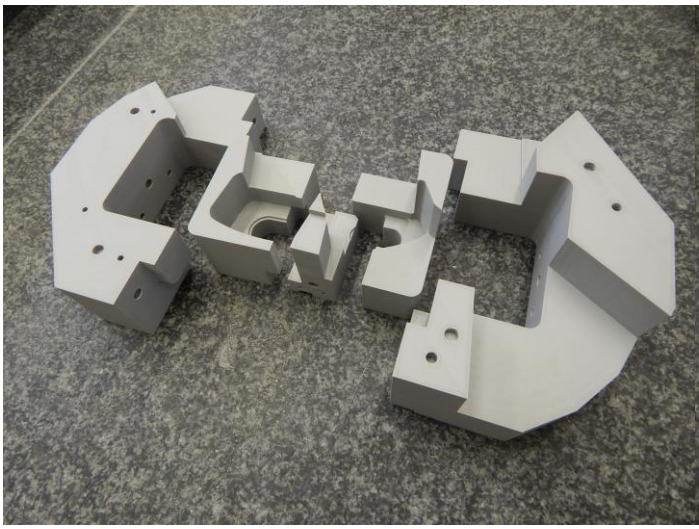
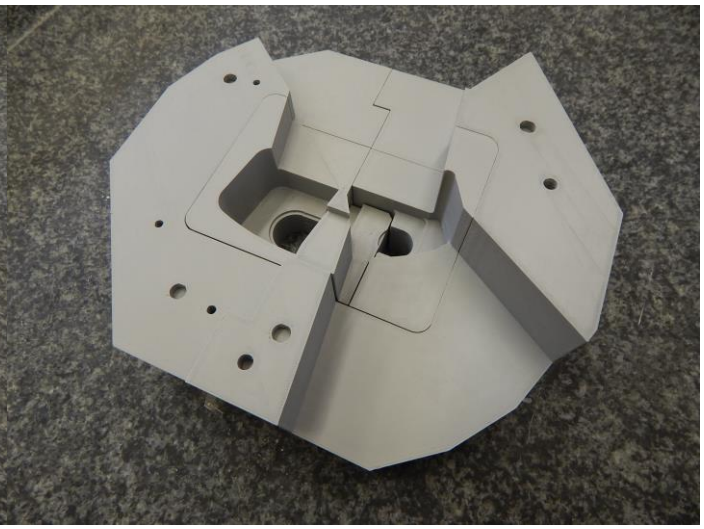
Larger parts:

If the printers available in the facility cannot print to the correct size you require. Consider if the part can be split into several pieces and attached together using bolts, magnets or simply glued together. Lap joints have been used in previous jobs and glued together in the facility. Often the parts are as strong as they would have been if printed as one piece due the flexibility of the material. We recommend the lap joints being at least 3 mm by 10 mm. If you're unsure we can advise on the best method.



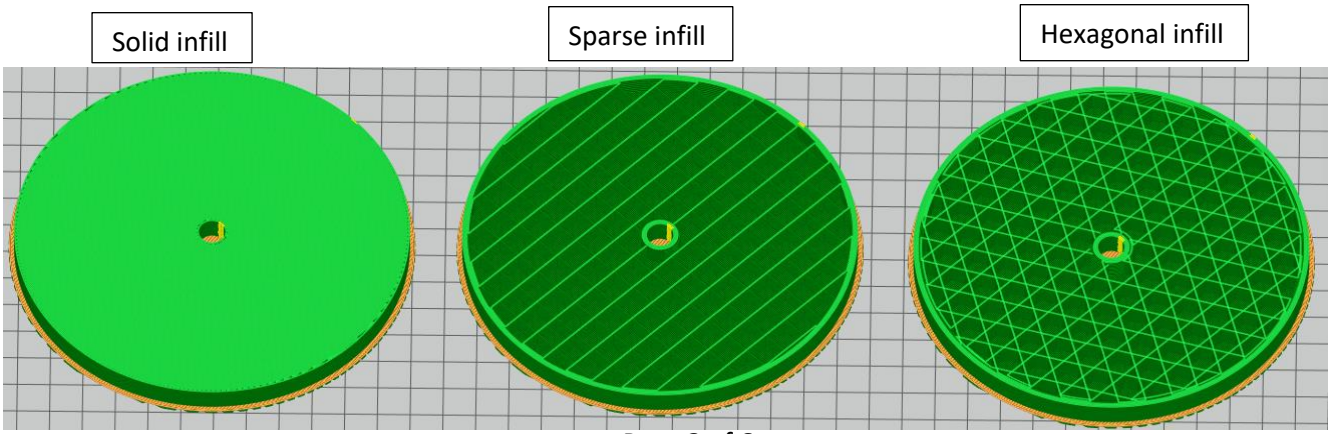






Infill Options:

It is important to consider the final function of your part. Depending on the design intent, your part may require to be made stronger or lighter. These options can be achieved using a variety of infill options. These options aren't something you have to design into the CAD they are added to the part by us. Below is an example of the different infill options. The internal air gap can be customised on the sparse and hexagonal infill to make parts lighter or stronger. Hexagon infill can also be used to improve strength in the X and Y build directions. A Solid infill is the strongest but also the most expensive.



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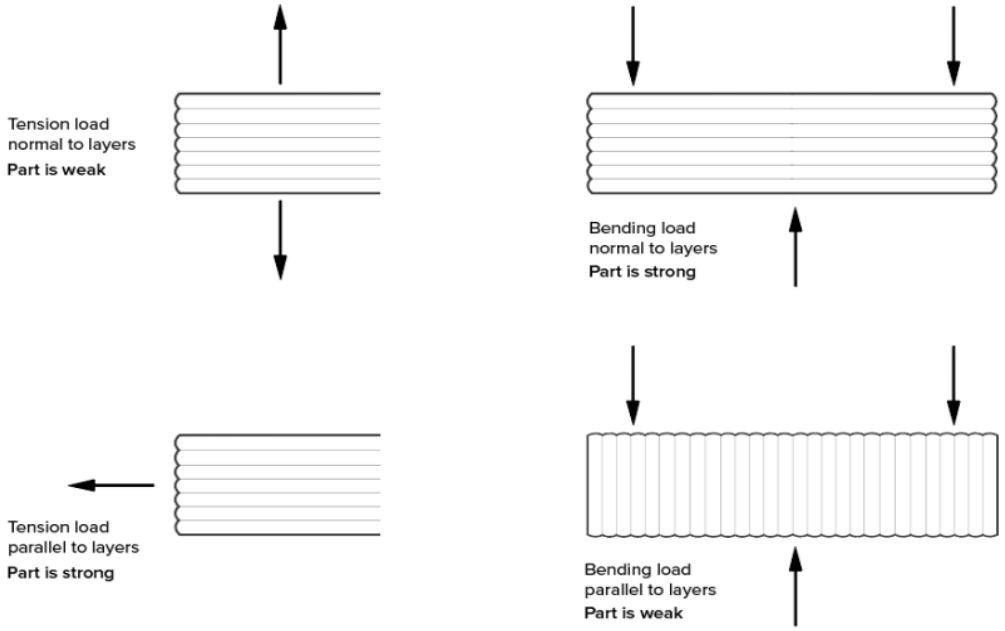
Build Direction:

Understanding the application and function of a component in the design process is critical to the build orientation. FDM printed components are always weaker in one direction due to layer orientation.

Due to the layer process and material paths the joints between each layer are actually small valleys. This creates a stress concentration where a crack will want to form and therefore contributes to this weakness. Its nest to contact the Additive Manufacturing Facility if you're unsure of the build direction. We're always happy to help.



General Tolerances:

When a part is 3d printed some features don't always print to the size required. We recommend the following size guidelines.

- For holes between 1 mm and 5 mm, make the holes 0.1 mm bigger before printing.
- For holes larger than 5 mm, make the holes 0.15 mm bigger before printing.
- For all shafts, make them 0.1 mm bigger before printing
- The smallest hole that can be printed is 1 mm.
- The thinnest wall that can be printed is 0.5 mm
- The smallest boss or shaft that can be printed is 1.0 mm however if printed as a separate pin, 3mm is recommended.

Important Details:

When sending a solid model for printing it is advisable that you supply the following information.

- Design Intent/function of the part
- Do any holes need to be tapped
- How many parts you require
- The date you need the parts by

When you send us an email please send your solid models preferably in .STP format. .STL format is acceptable but please note STL's are non-editable for any changes required before printing.
We also require a project code for any work undertaken so please also put this on your enquiry email.

Please send any 3d printing enquiries to:
sam.allum@stfc.ac.uk
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Below is a case study of a part for extra information.

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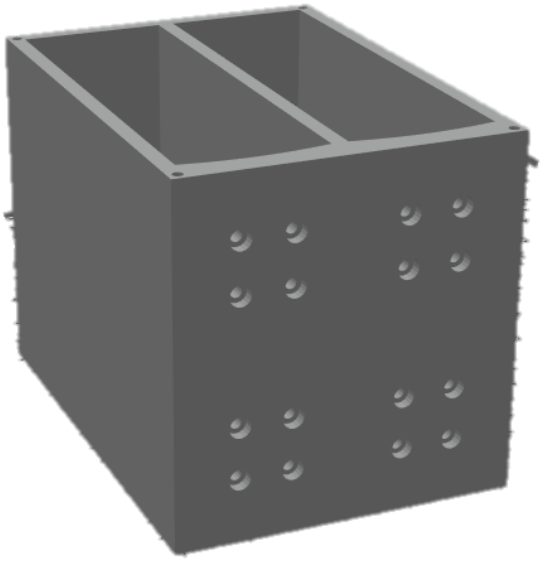
Example 1 of design changes

Foreword

The facility was approached by a customer wanting to print a box to transport delicate machined parts around various processes 'free-standing' and avoid any packaging coming in contact with the delicate surfaces on them. They will be bolted to the 3d printed box to protect them in transit.

Design



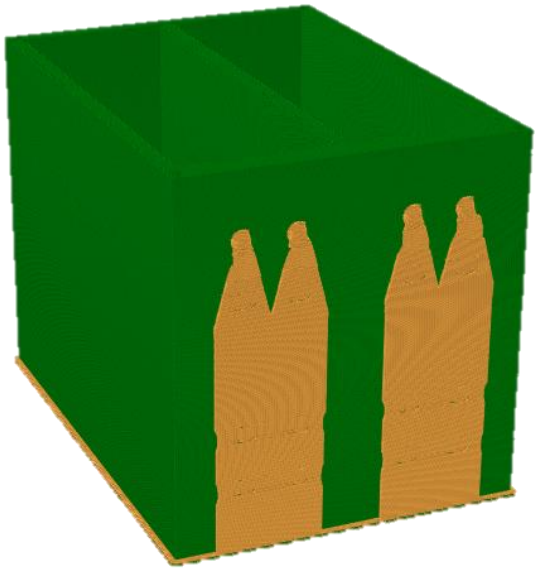
Example part

Printing Time= 13.5 hrs

Model material= 374.5

Support material= 37.3

Cost= £123.54



Example part in printing software

Green = Model material

Orange = Support material

Feedback Given

The holes in the part were for fasteners. The same feature can be achieved but made self-supporting. A 45 degree diamond doesn't require support material therefore all the holes could be changed to diamonds. If the holes are not through holes and require tapping diamond holes would not be suitable.

The part walls were thick. These could be thinned down using a cut out but the top and bottom of the cut outs needed to be chamfered at 45 degrees so they don't require support. Diamonds could also be cut into the side walls to reduce the amount of model material needed.

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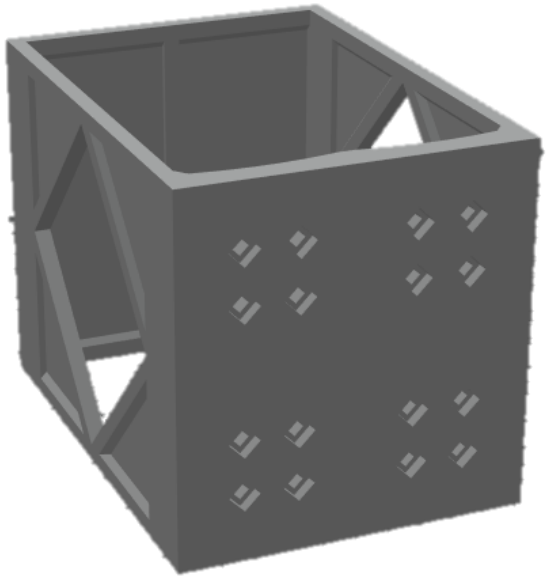
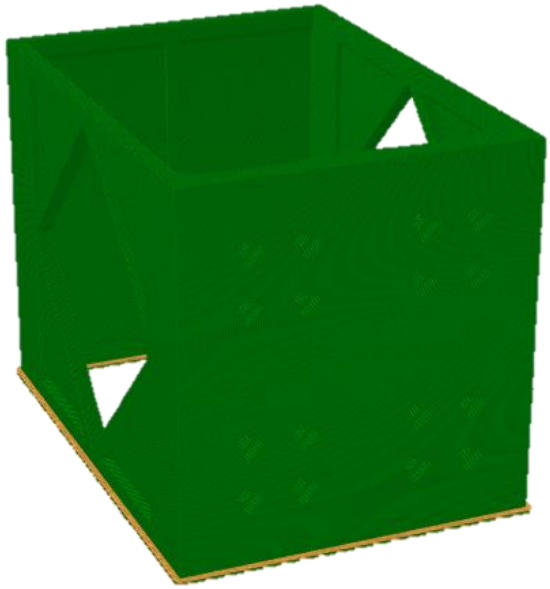
Redesign



Redesigned Example part



Re-designed Example part in printing software

Printing Time= 5.5 hrs

Model material= 185.8

Support material= 2.8

Cost= £56.58

Conclusion

The part cost was reduced by more than half and it functioned correctly with the design changes. The customer was very happy with the parts.