Structural Analysis of Angular Turns in 3D printing

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Fibre composites *Additive manufacturing* *Structural analysis*

Abstract: Angular paths and corners are common in toolpath designs in material extrusion additive manufacturing. As a nozzle turns on a corner, the shear and material flow could be affected[1]. For fibre reinforced composites, it also affects local fibre orientation and may be regarded as mechanical weakness points[2]. Here, we studied corner paths with short fibre reinforced materials regarding the fibre orientation and mechanical properties. We 3D printed corners with different turn angles (0º-150º). 3D fibre orientation tensor was measured, and main-axis alignment was low when it departed orthogonally, showing that fibres are highly aligned with the printing direction. The out-of-plane orientation increased with the angles, showing that sharper turns induced more Z-direction orientation. Tensile tests show decreasing specific strength with increasing turn angles and brittle to ductile failure. This study highlights the variation of fibre orientation at corners and reveals the variation in shear and flow. It may enlighten design strategies to control fibre orientation and avoid mechanical weakness. Additionally, a case study of single-wall capsules with different corner angles was conducted to further demonstrate the value of structural analysis of corners in 3D printing.

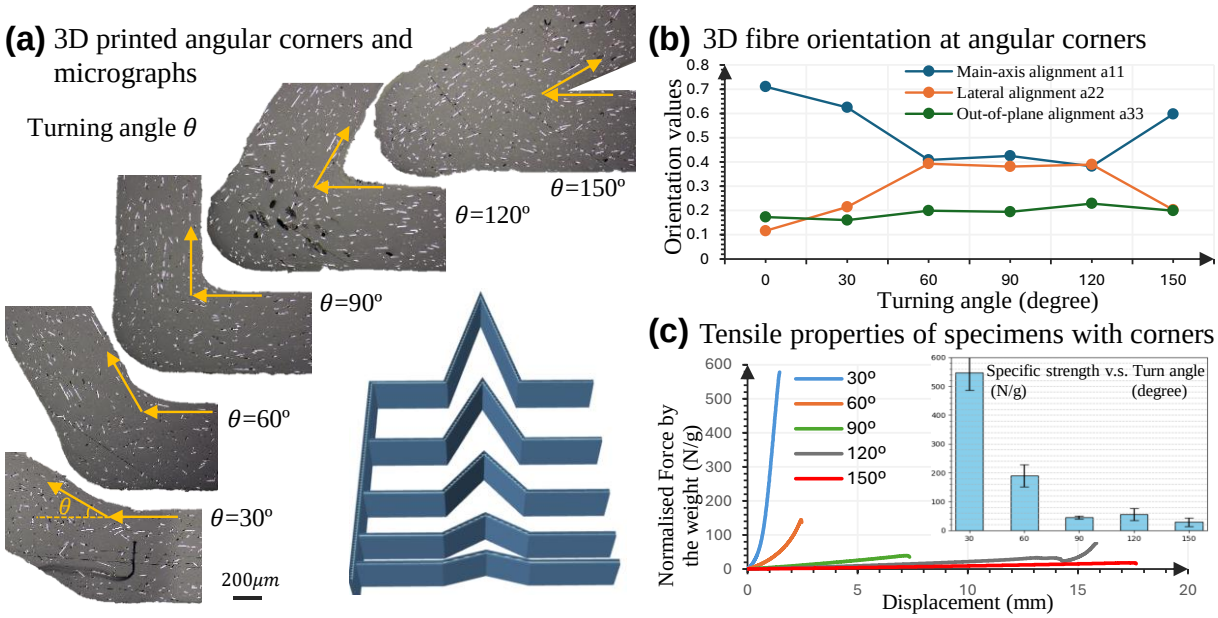

Figure 1. Structural analysis of 3D printed fibre composites at angular corners. (a) Micrographs of corners with different turning angles. (b) 3D fibre orientation at corners. (c) tensile properties (normalized force and specific strength) of corners.

References

[1] T. Mollah, A. Moetazedian, A. Gleadall, J. Yan, W. E. Alphonso, R. Comminal, B. Seta, T. Lock, J. Spangenberg, in *Solid Free. Fabr. 2022 Proc. 33rd Annu. Int. Solid Free. Fabr. Symp. Univ. Texas Austin*, **2022**, pp. 872–881.

[2] J. Yan, E. Demirci, A. Gleadall, *Addit. Manuf.* **2023**, *69*, 103535.

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