TENSILE, FRACTURE AND DAMAGE RESISTANCE CHARACTERISATION OF 3D PRINTED PLA WITH MORSE CODE ARCHITECTURES

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Fused deposition modelling (FDM) is one of the most popular additive manufacturing technologies. Therefore, understanding and improvement in mechanical properties and damage resistance of FDM fabricated structures have become important. In this study tensile and fracture properties of 3D printed PLA are quantified as function of, building direction, filling pattern and raster angle. Tensile strength and failure strain are found to be the same for hexagonal and line filling patterns. Highest fracture toughness and total damage resistance were found for the 90° raster angle [1] . In a previous study, Morse-code inspired architectures of dashes and dotes manufactured by laser machining in single edge notch bend specimens of a brittle polymethylmethacrylate (PMMA) were shown to improve damage tolerance of the material by 20-24 times [2]. In order to improve damage tolerance of 3D printed fabricated structures, a combination of dot and dash like architectures were printed. The dot-like features act a crack arrestors and the dash-like features work as crack deflectors. A combination of simulations and experiments have been performed to determine and quantify the effect of the size and arrangements of these features on crack driving force and fracture resistance. Crack initiation resistance has been defined in terms of initiation work of fracture per unit area (WOF_o) and overall damage resistance has been defined in terms of total work of fracture per unit area (WOF_T). WOF_o per unit area of bulk is the highest and shows maximum load bearing capacity while WOF_T is the lowest for bulk and highest for a combination of alternative layers of dashes and dots (Figure 1). A 1172% increase has been observed from WOF_o to WOF_T for SH case. This indicates that architecturing is an effective means to improve overall damage resistance of 3D printed structures.

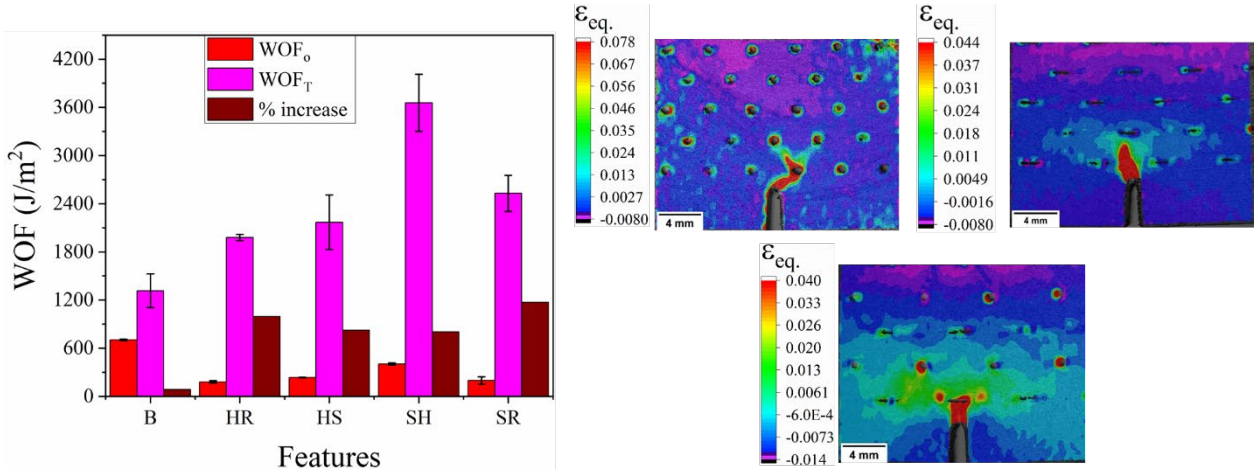

Figure 1 – Initiation and overall damage tolerance of 3D printed PLA with combinations of dot and dashes and crack trajectories for HR, SR and SH case.

[1] Yadav, Deepesh, Prerna Gupta, and Balila Nagamani Jaya. "Impact of Build Direction, Infill Pattern and Raster Angle on Mechanical Properties and Damage Tolerance of 3D Printed PLA." International Manufacturing Science and Engineering Conference. Vol. 86601. American Society of Mechanical Engineers, 2022

[2] D. Yadav, T. More, and B. N. Jaya, “Morse-Code inspired architectures for tunable damage tolerance in brittle material systems,” J. Mater. Res., vol. 37, no. 6, pp. 1201–1215, 2022, doi: 10.1557/s43578-022-00520-6