Phase field fracture modelling of 3d printed materials: an anisotropic analysis

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Additive Manufacturing is a technology which is more and more consolidated in both industry and academia for the chances that it offers. Among all the fields of application, the one regarding continuous Fibre deposition is among the most interesting since it allows the tailored reinforcement of regions which would be naturally subjected to stress concentrations. The possibility to know in advance the failure pattern of such 3D printed structure is of utmost importance in the design phase, which would need necessarily an experimental verification of the component realized in case no numerical simulations were available. On the other side, being the crack path that could originate from such geometry complex, an adequate numerical tool able to describe complex phenomena like crack nucleation, propagation, branching and coalescence is needed. In this sense, in this work the Phase Field approach to fracture is adopted. To study the ability of Phase Field to correctly predict the crack pattern and mechanical behavior, several numerical examples are taken into consideration, ranging from unidirectional notched specimens to variable stiffness ones, highlighting the validity of the approach.

Different numerical simulations are performed. In the first part of the work, the experimental evidence for unidirectional reinforced notched specimen and an Open Hole Tension specimen is replicated, finding good results both for crack pattern and mechanical response. In a second part, the approach is extended to variable stiffness composites, studying the influence the reinforcement has on the size effect. It is shown that the bigger the specimen, the larger is the beneficial effect resulting by the 'tailored deposition' of the continuous fibre in the variable stiffness specimens compared to the unidirectional ones, as shown in Figure 1.

The work underlines the capability of Phase Filed to predict the fracture behavior in such a complicated scenario like the one of continuous fibre deposition 3D printing. Therefore, the analysis presented here can be used as a general tool for the design of such components, leading the way to an application of composite 3D printing in industrial sectors.

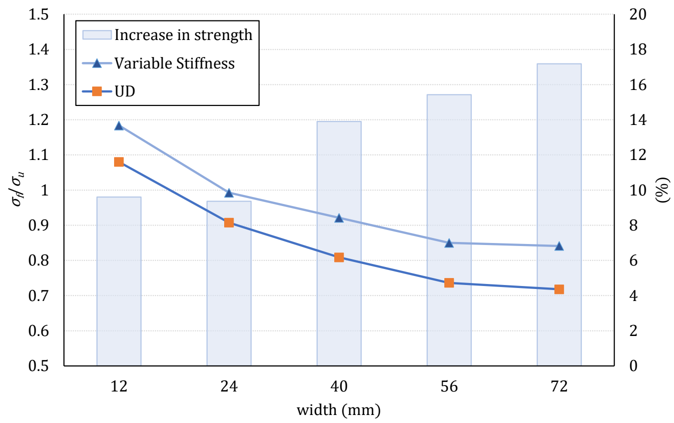

Figure 1 Size effect for the variable stiffness composite and improvement with respect to the unidirectional case.