Toughning effect of out-of-crack-path architected zones by apparition of snapback instability

J. Triclot[1]*, T. Corre[2], V. Lazarus[2], A. Gravouil[1],

[1] Univ Lyon, INSA Lyon, CNRS, LaMCoS, UMR5259, 69621 Villeurbanne, France
[2] IMSIA, ENSTA Paris, CNRS, EDF, CEA, Institut Polytechnique de Paris, 828 bd des Maréchaux, 91762 Palaiseau cedex, France

The rising of additive manufacturing has made it possible to build a new class of materials: architected materials. They are interesting for the industry because they can ally a relatively good resistance with a low density. In the context of this development, the question of the load-bearing capacity of these materials arises.

This work aims to tackle the problem of crack propagation in architected materials. This study focuses on remote effect of architected regions on crack propagation (Fig. 1). The question is to analyse how does the architecture modify the mechanical fields and has an effect on the crack tip and thus the propagation. This question is addressed in the framework of linear elastic quasi-static crack propagation, through finite element simulations with arc length algorithm [1]. The results are then validated using CT tests with 3D printed samples and digital image correlation for crack tracking [2].

The simulations allow bringing to light two important phenomena that can appear in this case: local slow down and snapback instability (Fig. 2). Local slow down refers to the fact that when the crack is between two architected zones, a larger displacement is required to propagate the crack than for the reference bulk sample.

The second phenomenon is the snap-back instability that appears at the end of the zone. In this work, we demonstrate that this is accompanied with an increase of dissipated energy by the crack propagation process. It means that the presence of the architected zone increases the total amount of external work needed to break the sample completely.

A parametric study is presented to understand the effect of the mechanical caracteristics of the architected zone on the two observed phenomena.

In this work, numerical models are used to prospect configurations and find toughening mechanisms made possible by architected materials. Experiments are used to validate that these phenomena effectively appear.

References

[1] M. A. Crisfield, A fast incremental/iterative solution procedure that handles ”snap-through”, Computers and Stuctures 13 (1981) 55-62.

[2] J. Triclot, T. Corre, A. Gravouil, V. Lazarus, Key role of boundary conditions for the 2d modeling of crack propagation in linear elastic compact tension tests, Eng Frac Mech 277 (2023) 109012.

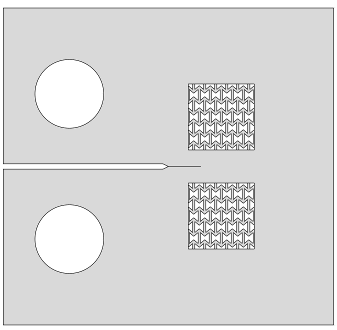

Figure 1: Geometry of the samples

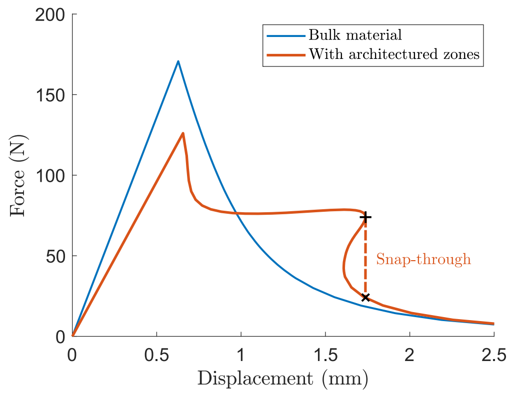

Figure 2: Numerically obtained loading curves