Toughening effects of out-of-crack-path architected zones

Veronique Lazarus*[1], Julie Triclot*[2,3], Thomas Corre[4,5], and Anthony Gravouil[3]

[1]Institut des Sciences de la mécanique et Applications industrielles – Centre National de la Recherche Scientifique - CNRS, Electricité de France - EDF, ENSTA Paris, Institut Polytechnique de Paris – 828 bd des maréchaux 91762 Palaiseau cedex France, France

[2]Centre Internacional de Mètodes Numèrics en Enginyeria – Spain

[3]Laboratoire de Mécanique des Contacts et des Structures [Villeurbanne] – INSA Lyon, France – France

[4]Institut de Recherche en Génie Civil et Mécanique – Nantes University, Ecole Centrale Nantes, CNRS, GeM, UMR 6183 – France

[5]Institut des Sciences de la Mécanique et Applications Industrielles – ENSTA Paris – France

Abstract

Architected materials have generated a lot of interest in the last two decades, both in the scientific community and the industry. This interest could be attributed to two main qualities: their high stiffness to weight ratio and their ability to display new behaviors. In this contribution, we aim to explore these new behaviors in the context of Linear Elastic Fracture Mechanics (LEFM). More specifically, we aim to analyze how the addition of architected zones adjacently to the crack path can remotely modify the crack propagation process. This problem is address in the framework of quasi-static LEFM with both numerical and experimental approaches. Numerically, finite element simulations with a path-following algorithm are performed to show that the architected zones have a complex and significant effect. An interesting configuration is found where the addition of the architected zones has two toughening effects (1). The first one is a temporary increase of the crack propagation resistance due to stored strain energy in the zones. The second one is snap-back instability that leads to a higher energy dissipated by the crack propagation process.

Experimentally, 3D-printed Tapered Double Cantilever Beam (TDCB) samples are tested with Digital Image Correlation (DIC) monitoring. The results demonstrate the possibility to reproduce the theoretically found toughening effects.

This study establishes a new way of using architected materials to improve the mechanical performance of a structure while reducing its weight. It opens up prospects of shape optimization for practical purposes and eventually be able to finely tune the crack propagation response.

(1) Triclot, J., Corre, T., Gravouil, A., Lazarus, V. Toughening effects of out-of-crack-path architected zones. *Int J Fract* (2024). https://doi.org/10.1007/s10704-024-00811-5

*Speaker