Benchmarking of strength models for unidirectional composites under longitudinal tension

Anthony Bunsell, Larissa Gorbatikh, Hannah Morton, Soraia Pimenta, Ian Sinclair, Mark Spearing, Yentl Swolfs, Alain Thionnet

PII: S1359-835X(18)30118-0
DOI: https://doi.org/10.1016/j.compositesa.2018.03.016
Reference: JCOMA 4973

To appear in: *Composites: Part A*

Received Date: 22 June 2017
Accepted Date: 10 March 2018

Please cite this article as: Bunsell, A., Gorbatikh, L., Morton, H., Pimenta, S., Sinclair, I., Spearing, M., Swolfs, Y., Thionnet, A., Benchmarking of strength models for unidirectional composites under longitudinal tension, *Composites: Part A* (2018), doi: https://doi.org/10.1016/j.compositesa.2018.03.016

Benchmarking of strength models for unidirectional composites under longitudinal tension

Anthony Bunsell[a], Larissa Gorbatikh[b], Hannah Morton[c], Soraia Pimenta[d,*], Ian Sinclair[c], Mark Spearing[c], Yentl Swolfs[b], Alain Thionnet[a,e]

[a]*Mines ParisTech, PSL Research University, Centre des Matériaux, CNRS UMR 7633, BP 87, 91003 Evry, France*
[b]*Department of Materials Engineering, KU Leuven, Kasteelpark Arenberg 44, 3001 Leuven, Belgium*
[c]*Material's Research Group, University of Southampton, University Road, Southampton SO17 1BJ, United Kingdom*
[d]*Dept Mechanical Engineering, South Kensington Campus, Imperial College London, SW7 2AZ, United Kingdom*
[e]*Université de Bourgogne, Bâtiment Mirande, BP 47870, Dijon, France*

Abstract

Several modelling approaches are available in the literature to predict longitudinal tensile failure of fibre–reinforced polymers. However, a systematic, blind and unbiased comparison between the predictions from the different models and against experimental data has never been performed. This paper presents a benchmarking exercise performed for three different models from the literature: (i) an analytical hierarchical scaling law for composite fibre bundles, (ii) direct numerical simulations of composite fibre bundles, and (iii) a multiscale finite–element simulation method. The results show that there are significant discrepancies between the predictions of the different modelling approaches for fibre–break density evolution, cluster formation and ultimate strength, and that each of the three models presents unique advantages over the others. Blind model predictions are also compared against detailed computed–tomography experiments, showing that our understanding of the micromechanics of longitudinal tensile failure of composites needs to be developed further.

Keywords: A. Polymer–matrix composites, B. Fragmentation, B. Strength, C. Micro-mechanics.

1. Introduction

Composites are a rapidly growing class of materials for lightweight, high-performance applications. However, composite components are often overdesigned, which leads to sub-optimal performance and hence larger and heavier parts. A reason for this overdesign is the lack of reliable predictive models for the mechanical response of composite materials, which is directly linked to an incomplete understanding of their failure mechanisms. Since composites consist of reinforcing fibres inside a

*Corresponding author.
Email addresses: anthony.bunsell@mines-paristech.fr (Anthony Bunsell), larissa.gorbatikh@kuleuven.be (Larissa Gorbatikh), h.morton@soton.ac.uk (Hannah Morton), soraia.pimenta@imperial.ac.uk (Soraia Pimenta), i.sinclair@soton.ac.uk (Ian Sinclair), s.m.spearing@soton.ac.uk (Mark Spearing), yentl.swolfs@kuleuven.be (Yentl Swolfs), alain.thionnet@mines-paristech.fr alain.thionnet@u-bourgogne.fr (Alain Thionnet)