Inter-ply angle influence on the out-of-plane compressive response of polyethylene laminates

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PII: S1359-835X(18)30134-9
DOI: https://doi.org/10.1016/j.compositesa.2018.03.032
Reference: JCOMA 4989

To appear in: *Composites: Part A*

Received Date: 17 January 2018
Accepted Date: 23 March 2018

Please cite this article as: O'Masta, M.R., Russell, B.P., Ronan, W., Inter-ply angle influence on the out-of-plane compressive response of polyethylene laminates, *Composites: Part A* (2018), doi: https://doi.org/10.1016/j.compositesa.2018.03.032

Inter-ply angle influence on the out-of-plane compressive response of polyethylene laminates

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Abstract

Ultra-high molecular weight polyethylene (UHMWPE) fibre reinforced composites find extensive use in impact protection applications. When loaded in out-of-plane (through thickness) compression, UHWMPE laminates composed of a typical cross-ply lay-up (an inter-ply angle of θ = 90°) are known to exhibit fibre tensile rupture via a shear-lag mechanism. This study addresses the effect of inter-ply angle (θ = 18° to 90°) on the compressive response of UHMWPE laminates and shows they may fail by this indirect tension mechanism. The shear-lag length increases as θ is reduced, which reduces the compressive strength at small sample sizes. A previous analytical model to predict compressive failure by this mechanism is generalised for laminates with non-orthogonal but constant inter-ply angles. The predictions capture the two key experimental observations which are dependent on inter-ply angle and sample size: the transition from ply shear failure to indirect fibre tensile rupture and the compressive strength.

Keywords:

A. Polymer-matrix composites; B. Laminate strength; C. Analytical modelling; D. Shear-lag

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