11th International Conference on Composites Testing and Model Identification
J. Costa, J. Renart and N. Blanco (Editors)
Girona, 2023

EXPERIMENTAL INVESTIGATION OF THE LOADING RATE DEPENDENCY OF THE NON-LINEAR DAMAGEABLE BEHAVIOUR OF CARBON/EPOXY LAMINATES

Jordan Berton[1], Fabien Coussa[1], Julien Berthe[1], Eric Deletombe[1] and Mathias Brieu[2]

[1] ONERA - DMAS
5, rue des Fortifications - CS 90013 - 59045 LILLE CEDEX
Email: julien.berthe@onera.fr, web page: http://www.onera.fr

[2] Department of Mechanical Engineering, California State University
Los Angeles, CA 90032, USA
Email: mbrieu@calstatela.edu

Keywords: Non-linear behaviour, Damage, Dynamic testing, Characterisation

ABSTRACT

The problematic of the presented work is part of a context, where the design of composite structures subjected to a crash or an impact, requires to improve the predictivity of numerical simulations with respect to the sensitivity of the evolution of the degradation mechanisms in the presence of important strain rate gradients. While the influence of increasing loading velocity on the reversible shear behavior of CMOs has been the subject of much work [1], a limited amount of study is available in the literature regarding the mechanical characterization of irreversible nonlinear behavior over a wide range of strain rate [2, 3].

Due to the inherent experimental complexity of dynamic testing and the absence of a normative consensus, this work aims at proposing a complete experimental procedure dedicated to the study of the damageable non-linear behavior of the T700/M21 composite material, subjected to an in-plane shear stress loading on a large range of strain rate from quasi-static to intermediate dynamic. Using a specimen geometry adapted to dynamic tests and whose mechanical response has been fully validated against a normative geometry [4], an experimental protocol allowing to interrupt a dynamic tensile loading and to preserve the associated degradation state in the specimen has been developed. By increasing and successive increments, the discretization of the evolution of the irreversible behavior is made possible for different loading rates.

The major results associated with this study are illustrated on the one hand, in the capacity of the protocol to guarantee the robustness of the characterization of the effects of speed on the damage phenomena, in particular by the realization of physically justified recovery times (allowing the reduction of viscoelastic phenomena) for each increment of discretization (Figure 1).

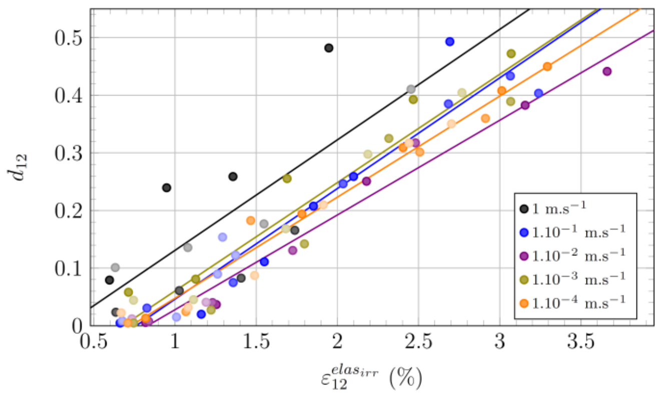

Figure 1: Velocity sensitivity of the macroscopic damage variable as a function of the elastic deformation variable evaluated after a waiting time allowing the reduction of viscoelastic phenomena

On the other hand, the access to the physical observation of the degradation mechanisms at the mesoscopic scale, for each increment and each strain rate, allows to deepen the analysis of the velocity effects and to bring a nuance as for the relative insensitivity of the phenomena considered at the macroscopic scale.

REFERENCES

[1] Parry, S., Fletcher, L., & Pierron, F. (2021). The off-axis IBII test for composites. *Journal of Dynamic Behavior of Materials*, *7*(1), 127-155.

[2] Jendli, Z., Meraghni, F., Fitoussi, J., & Baptiste, D. (2004). Micromechanical analysis of strain rate effect on damage evolution in sheet molding compound composites. *Composites Part A: Applied Science and Manufacturing*, *35*(7-8), 779-785.

[3] Coussa, F., Renard, J., Joannes, S., Teissedre, J. C., Bompoint, R., & Feld, N. (2017). A consistent experimental protocol for the strain rate characterization of thermoplastic fabrics. *Strain*, *53*(3), e12220.

[4] Berton, J., Coussa, F., Berthe, J., Brieu, M., & Deletombe, E. (2022). Definition of [±45°] ns specimen geometry to characterize CFRP non-linear shear behavior in dynamic loading. *Composites Communications*, *30*, 101096.