TRANSNVERSE COMPRESSIVE PROPERTIES OF NATURAL FIBRES DETERMINED USING MICRO MECHATRONICS SYSTEMS AND 2D FULL-FIELD MEASUREMENTS

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ABSTRACT

This work is focused on the determination of the transverse compressive properties of bio-based polymeric monofilaments (PA11) and plant fibres using an innovative micro mechatronics system and 2D full-field measurements at the microscale. Using the data collected from this single fibre transverse compression test and the single fibre tensile test, results show that the three main elastic properties (i.e. longitudinal and transverse moduli and major Poisson's ratio) can be accurately and reliably determined.

INTRODUCTION

One of the main shortcomings of current knowledge on plant fibres is related to their transverse mechanical properties. To the best of the author's knowledge, no data determined by direct methods can be found in the open literature. Only values determined by back-calculation from tensile tests realised in the transverse direction of unidirectional composite materials (Baley et al., 2006) are available. More generally, literature on the transverse mechanical properties of synthetic monofilaments is sparse compared with the voluminous data on their longitudinal properties. In this study, we propose to develop an experimental device and methodology to accurately determine the transverse compressive properties of polymeric monofilaments and plant fibres. This compression experimental test is commonly called as « Brazilian » test or as Fibre Transverse Compression Test (FTCT) and has been proposed and developed since the 60's (Hadley et al., 1965). It has been mainly applied on single synthetic fibres and textile fibres assemblies, so far. In most of the works, the fibres and monofilaments are assumed as perfectly cylindrical and made of elastic isotropic of transversely isotropic material. The problem is treated as for two semi-infinite solids in contact (Hertz) under conditions of plane strain. Literature points out that conducting such experiments on small diameter polymeric fibres is really challenging. Indeed, their small diameter and low modulus make the test specimen very compliant per length unit. The tests require also an accurate alignment and measurement of platen displacement. In addition, this experiment is very sensitive to the geometry of the contact between fibre and platen and consequently on variations in the fibre diameter. The transverse compressive modulus is generally identified by inverse method using analytical models (Jawad & Ward, 1978). For anisotropic materials, the model is sensitive to the other elastic properties (longitudinal elastic modulus and major Poisson's ratio). To cope with these difficulties, a specific methodology and the associated device were developed. It comprises a set-up based on micro mechatronics system and 2D full-field strain measurements at the microscale. The longitudinal elastic modulus and the major Poisson's ratio are first determined using single fibre tensile tests. The transverse elastic modulus is then determined from the FTCT and more exactly from the measured compressive load, the 2D full field displacement and the Kolosov-Muskhelishvili formulation.

RESULTS AND CONCLUSIONS

Fig. 1 shows some pictures of the developed set-up, the transverse cross-section of a PA11 monofilament tested, and the measured load-displacement curve.

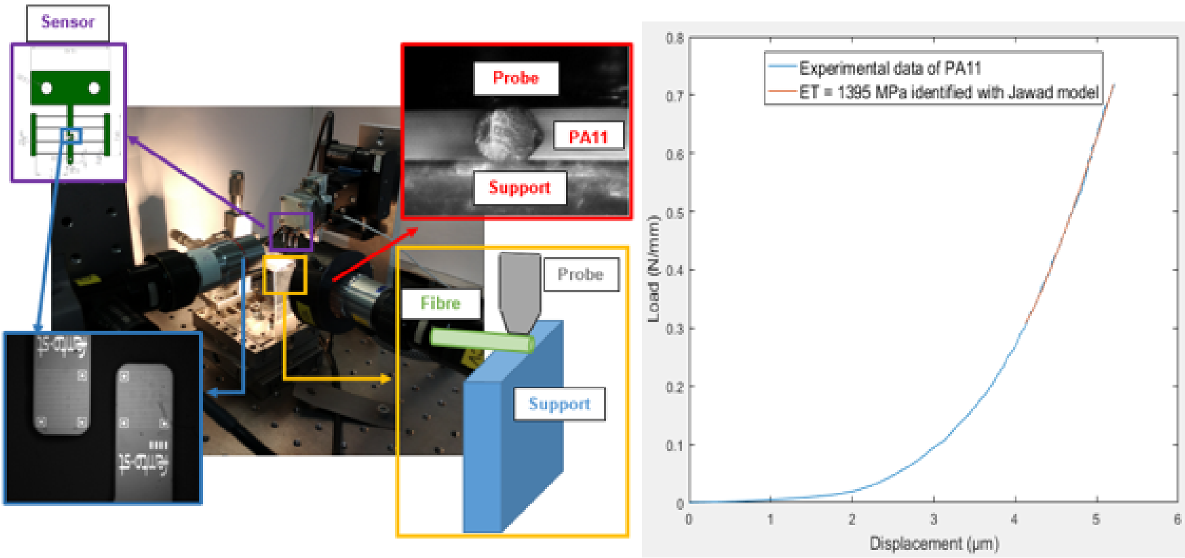

Fig.1 Transverse compressive set-up and results obtained on Pa11 monofilament

The first tests were performed on Polyamide 11 (PA11) monofilaments, with an average diameter of approximately 40 µm. The elastic longitudinal modulus, determined using single fibre tensile tests, is equal to approximately 2100 MPa. The transverse compressive elastic modulus identified from the analysis of the 2D full field displacement field recorded during compression tests is approximately 1450 MPa. The presentation will also include preliminary results obtained on plant and animal fibers.

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