In-service tensile creep/recovery behaviour of high-grade hemp and flax fibre reinforced GreenPoxy composites

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ABSTRACT

The aim of this work is to investigate the tensile creep/recovery behaviour of two high-grade flax and hemp fibres reinforced GreenPoxy matrix composites under constant and varying conditions similar to the one experimented during in-service use. Results show the strong influence of environmental conditions on the time-delayed behaviour of these materials as well as the existence of mechanosorptive couplings.

INTRODUCTION

Plant fibre composites represent a suitable solution for the development of sustainable lightweight structures. For several years, plant fibre reinforcements have been used in various composite application sectors such as sports, design and transport (Pil *et al.* 2016). However, the mechanical potential of these materials is not fully exploited. Although some of these biosourced fibres, such as hemp and flax, have specific mechanical properties that are superior to those of glass fibres (Mohanty *et al.* 2002), plant fibre composites are rarely used in structural applications. This is mainly due to some locks and limited knowledge and understanding of their in-service behaviour, including: (i) the impact of various and varying environmental conditions on the mechanical behaviour (Abida *et al.* 2020), (ii) the limited data concerning the time-delayed behaviour, and (iii) the lack of statistical description of the mechanical properties of the materials necessary to achieve reliability analysis (Blanchard et Sobey 2019). This work intends to shed light on these points. This study is in particular focused on the evaluation of the impact of constant and varying hygrothermal conditions on the creep/recovery behaviour of two high-grade composites manufactured with GreenPoxy matrix: a cross-ply laminate made with a flax tape and a laminate made with balanced satin woven hemp fabric.

RESULTS AND CONCLUSIONS

The evolution of the strain during the creep/recovery tests in two constant environmental conditions, 23°C-50%RH and 70°C-85%RH, are represented in Fig. 1 a) and b), respectively. Under ambient environment, the time-delayed behaviours of the two composites are relatively close with an average maximum strain at 0.63% and 0.65% for the flax and hemp reinforced composites respectively. Residual strain, around 0.1% for both composites, is also visible at the end of the recovery phase. The strain response of the materials is greatly impacted by more severe conditions. Indeed, the average maximum strain of flax and hemp fibre composites is multiplied by 1.5 and 3.5 respectively, while the level of the residual deformation is 3 times and 10 times higher than for ambient conditions, respectively. In contrast to the ambient conditions tests where material failure occurs suddenly (Jia et Fiedler

2020), a tertiary creep stage can be observed before the failure of the specimen at 70°C-85%RH.

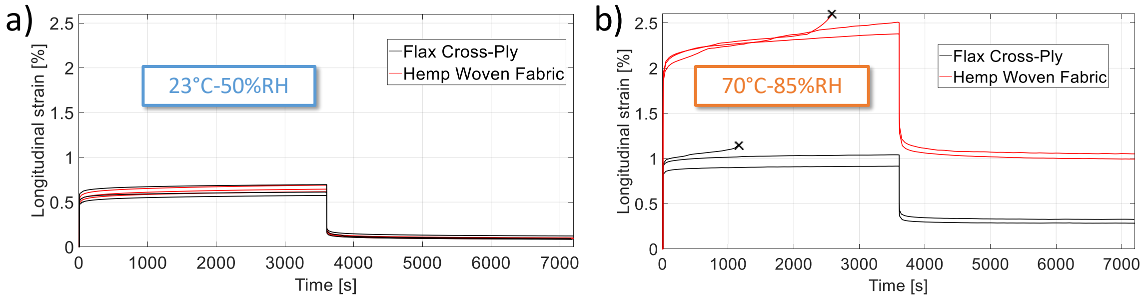

Fig.1 Evolution of the strain of the cross-ply composite reinforced with flax fibre and the hemp woven fabric reinforced composite during a creep/recovery test under environmental condition 23°C-50%RH **a)** and 70°C-85%RH **b)** at a nominal stress of 70 MPa. (Crosses represent the failure of the specimen)

Using these experimental results, the parameters of an anisotropic viscoelastic model are identified by inverse method. The spread of these viscoelastic properties measured on a large number of specimens is represented using statistical models. Additional results of creep collected under varying controlled hygrothermal conditions as well as under real hygrothermal conditions during several months will also be presented during the conference. All these results provide a better understanding of the mechanosorptive behaviour exhibited by these plant fibre composites.

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