
A transversely isotropic bimodular elasto-visco-plastic model for polymeric yarns and cords

Marco Moscatelli*¹, Claudia Comi², Giorgio Novati³, Lucas Pires Da Costa³, and Paola Caracino⁴

¹Institut Jean Le Rond d'Alembert, F-75005 Paris, France – Sorbonne Université, CNRS – France

²Department of Civil and Environmental Engineering, Politecnico di Milano, 20133 Milano – Italy

³Department of Civil and Environmental Engineering, Politecnico di Milano, 20133 Milano – Italy

⁴RD Materials, Reinforcements Group, Pirelli Tyre SpA, Milan, Italy – Italy

Abstract

Polymeric yarns are made up of hundreds of textile filaments (or fibers) twisted together. Typically, yarns (of the same or different fibrous materials) are then twisted together to form cords, also known as multi-ply yarns. These 1D structural elements possess high flexural flexibility while having high stiffness and strength in the longitudinal tensile direction, making them an optimal solution as reinforcements in composite materials.

This work aims to present a mesoscopic 3D mechanical model to predict the mechanical behavior of this class of fibrous structural elements. Specifically, yarns and cords are here treated as transversely isotropic elasto-visco-plastic continua, with a bimodular elastic stiffness to account for the different behavior under tensile and compressive conditions.

The model is built under the framework of generalized standard materials, using the theory of structural tensors (1) under the assumption of small perturbations, and is implemented in a finite element code. Its capabilities are assessed by comparing the results of numerical simulations and experimental tests carried out in Pirelli's laboratories. As shown in (2) and (3), starting from the material behavior at the level of the fibers, and including geometric effects, we can effectively predict the behavior of the aforementioned class of fibers-based structural elements in different stress conditions.

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*Speaker