3SR Seminars

31/05/2024 at 10:30 a.m. | Guilhem BLES | Galilée room 015

Modelling the friction between yarns within a laid-strand synthetic ropes by hyperelastoplasticity in finite deformation

Criscione et al. [1] have proposed a set of 5 strain invariants in the case of transversely isotropic material and in finite deformation. A great outcome of this proposition is that each strain invariant describes a relevant strain mode for transversely isotropic material. So that, each strain invariant is not coupled with another, and this even for large deformations. This work has a very interesting application for modelling the mechanical behavior of any material composed of fibers packed against each other. For example, the steel wire cables, any textile material made of continuous-filament twisted yarns or strands. Indeed, in this case of materials, the third strain invariant (cross-fiber shear) and the fourth invariant (along-fiber shear) describe strain modes where a sliding between the fibers in contact with each other should occur. So, these invariants allow us to implement several behavior laws, each one dedicated to a strain mode and so to its associated physics. For example, third and fourth invariants describe the sliding between the fibers by shear strains. So, we may implement an elasto-plastic type law for modelling the elastic stick and friction slip at the contact between fibers. Charmetant et al. [2] used Criscione's strain invariants and proposed a hyperelastic behavior law for a material of glass-fiber packed together; a glass-fiber bundle. They applied this law for modelling the mechanical behavior of a woven fabric made of glass-fiber yarns. Also, Criscione et al. proposed their strain invariants with a view to hyperelastic laws. But, the hyperelasticity is not relevant for modelling the friction between the fibers. So, we proposed a continuation of Criscione's proposition of set of strain invariants. A hyperelasto- plastic law can model the dissipated energies due to the frictions between the fibers within the deformed fiber bundle. Firstly, the number of independent degrees of freedom for all comprehensive friction strains is four and not two as described by Criscione (third and fourth strain invariants). Secondly, the plasticity, introduced in this way, will be dependent on the loading path and the partial isotropy, assumed by the third and fourth invariants of Criscione, will no longer be true. This is why we proposed four strain variables instead of the third and fourth invariants of Criscione et al. This is the point of the Fiber Bundle Law (FiBuLa), proposed here [3].

[1] J.C. Criscione, A.S. Douglas, W.C. Hunter, J Mech Phys Solids, 49, 871 (2001).
[2] A. Charmetant, E. Vidal and P. Boisse, Compos Sci Technol, 71, 1623 (2011).
[3] L. Civier, Ph.D. Thesis, (E. doct. SPIN, ENSTA Bretagne, 2023).