The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

Computational homogenization of spiral strands using 1d finite strain beam elements

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Key Words: *Computational homogenization, Spiral strand, beam element, finite strain*

As spiral strands often consist of a large number of wires, the simulation of their mechanical behaviour considering samples of reasonable length may become out of reach for computational cost reasons. In order to circumvent this issue and to propose an alternative approach, this study presents a computational homogenization scheme for spiral strands using 1d finite strain beam elements at both scales. At the macroscopic scale, the spiral strand is modeled using only one homogenized beam element, the constitutive behavior of which is obtained from solving the boundary value problem of the representative volume element (RVE). At the RVE level, all the microstructural constituents of the spiral strand are modeled by considering all the interwire interactions. Due to the use of 1d element at the macroscale, homogenization is performed only in the direction of curvilinear abscissa and modified averaging conditions for the deformation gradient are introduced, from which the appropriate boundary conditions are extracted. As the bending stiffness of spiral strands depends on the tension, a strain- and/or stress-driven homogenization scheme should be utilized to model this dependency. Therefore, the macroscopic Green-Lagrange strains are introduced as a set of additional degrees of freedom in the microscale boundary value problem, with the macroscopic second Piola-Kirchhoff stresses as their conjugate forces. Examples demonstrating the relevance of the approach will be presented.

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