Large deformations of planar periodic trusses with rheological non-linearity

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Abstract

Both geometrical and rheological non-linearities can be involved in highly deformable trusses. The aim of this paper is to derive explicit descriptions of the plane behavior of periodic trusses subjected to both non-linear effects.

The trusses under consideration are composed of bars that only support axial forces and that are connected by perfect hinges. Assuming a large scale evolution of the deformation, the homogenization method allows the macroscopic behaviour to be determined. In fact, although the deformed configuration differs significantly from the initial one, the homogenization can is still be carried out on parametric Lagrangian variables, taking advantage of the periodicity of the initial configuration. The procedure uses a variational approach similar to that introduced in (Caillerie et al. 2006), (Raoult et al. 2008) and (Gazzo et al. 2020). This approach, applies to trusses of any topology, and in particular to trusses whose cells contain a single node. In that case the equilibrium conditions (expressed in the deformed configuration) of the node and the cell coincide. This allows to formulate analytically the constitutive laws at large deformations can be established, and this equally well to bars with linear ornon-linear behavior.

For linear elastic bars, the non-linear effect is due to geometric non-linearities alone. For stiffening or softening elastic behavior, the two non-linear effects interact. It should also be noted that these media are by nature highly anisotropic. All these characteristics lead to very rich behaviors, as illustrated by some examples. Having an explicit model that takes into account the morphology of the cell, the constitutive law of its constituents and its evolution at large deformations allows to have a deep understanding of the physical interaction of these mechanisms.

This study can be extended in various ways, e.g., by considering cells composed of bars of different types (visco-elastic trusses), by introducing buckling instability, by considering 3D truss networks, or by imposing rigid connections between the elements and replacing the bars by bending beams.

References

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