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Numerical multi-scale modelling of composite plates

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Composite plates, such as sandwich structures or hybrid laminates, are widely used in the field of transport industry, due to their outstanding mechanical properties for a relatively reduced weight. However, they show a complex material behaviour, which can not be properly described by using a simple mixture rule. Moreover, it can be necessary to model non-linear material behaviour -like for instance plasticity- if dealing with a forming process. Due to the restriction of most of the plate theories to linear material behaviour, the development of a numerical multi-scale modelling of composite plates is of interest.

In the presented work, the modelling of the mechanical behaviour of composite plates is based on a numerical homogenisation, or so-called FE^2, for composite plates. The principle is to split the problem into two characteristic scales: on the one hand, the macroscale, containing the kinematics of the plates, and on the other hand, a so-called mesoscale, discretizing the layers stacking order with their individual properties.

In this work, special attention is paid towards the definition of the analytical tangent using the Multi-Level Newton Algorithm (MLNA) and towards the resolution of the Poisson's thickness locking phenomenon, enabling the consideration of the thickness change by an improved projection strategy. The validity of the proposed method towards linear and non-linear material behaviour is verified using various numerical experiments.