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A FILTER-BASED MULTISCALE HOMOGENIZATION METHOD FOR COMPOSITE STRUCTURES WITHOUT SCALE SEPARATION

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The assumption of scale separation is essential in computational homogenization. It means that the characteristic wavelength of the applied load needs to be large as compared to the dimension of the heterogeneities. When this assumption does not hold, the micro kinematic fields may not be captured with sufficient accuracy. This is the case of some industrial structures, for example 3D woven composite fan blades used in the LEAP (Leading Edge Aviation Propulsion) engine, where the size of the waving patterns at the mesoscale is comparable to which of the macrostructure. In addition, due to the manufacturing process, local variations of the mesostructure (e.g. shearing) may appear that affect the macrostructural response. Therefore the main objective of this study is to develop a new multiscale homogenization method to determine the mechanical response of composite structures without scale separation.

A suitable method for this purpose is the filter-based multiscale homogenization [1,2]. In this method, the strain and stress fields at the micro and macro scales are related through a numerical filter used to cut off the micro-fluctuations. The averaging operators used in the classical homogenization are replaced by filter operators, based on finite element shape functions, and computed on a coarse mesh. The behavior of the unit cell is then non-local, which allows to take into account the influence of the fluctuations of a mesoscopic strain field at the scale of the representative volume element. In this work, the method is extended to 3D and non-regular meshes to describe both the micro and the macro scales. A comparison procedure with the classical homogenization has demonstrated that the global errors of reconstructed local fields are significantly reduced using filter-based homogenization. Numerical examples of structures without scale separation, including 3D woven composite structures, will be presented in which the local stress and strain fields are well captured by the present method.

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