FE·Meshless multiscale modeling of heterogeneous periodic materials

Giuseppe Giambanco[1], Antonino Spada[1], Emma La Malfa Ribolla[1], Manuela A. Scamardo[1]
[1]*Department of Civil, Environmental, Aerospace materials Engineering, University of Palermo, Italy*
E-mail: *giuseppe.giambanco@unipa.it, antonino.spada@unipa.it, emmalamalfa@gmail.com, manuela.scamardo@gmail.com*

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The computational mutiscale modeling of periodic heterogeneous materials, characterized by the assembly of units and joints, represents a compromise between the inaccuracy resulting from the macro modeling approach and the computational effort of the meso modeling.

Assuming that the heterogeneities are orders of magnitude smaller than the structure dimensions, according to the multiscale approach, the macroscopic stresses and strains around a certain point can be found by averaging the stresses and the strains in a small representative part of the microstructure or a representative volume element (RVE) attributed to that point. A first-order two-scale scheme has been used to model heterogeneous polymers [1] or masonry panels [2]. The macroscopic strain is evaluated at each integration point and then is transferred to the RVE at the mesoscale as essential boundary conditions (*macro-meso scale transition*). As a result of the mesoscopic equilibrium problem, the RVE stress field is available and, by averaging it, the macroscopic stress is obtained (*meso-macro scale transition*). Thus, a new homogeneous material is created without using complex closed form constitutive relation for the representation of its behavior. As the model is based on the use of two scales, two different numerical approaches are employed: the finite element method at the macroscopic level and the meshless approach [3] at the mesoscopic one. The meshless method involves the construction of an approximated function of the displacements field, based on the values obtained in correspondence to several nodes, arbitrarily chosen in the domain and with specific domains of influence. The moving least square approximation is adopted for the construction of this function. In the present work the RVE is composed by the aggregate and the surrounding adhesive joints, which are simulated by zero-thickness interface models. The non linear behavior of the heterogeneous material results from the inelastic deformation mechanisms occurring at the interfaces, while the units behaves elastically. The interface laws are formulated in the framework of elastoplasticity in order to simulate the softening response which occurs along the decohesion process in presence of shear and tensile tractions. The elastoplastic model is developed in a thermodynamically context and for plane stress applications. Numerical examples show the main features of the multiscale model and the novelties introduced.

References

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