Non-Linear Multiscale Homogenization with the Virtual Element Method

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ABSTRACT

The overall characteristics of complex composite materials strongly depend on processes that are occurring at different length scales. The analyses of various scale-levels are required to account for the different mechanisms that control the behaviour at the different levels of detail. For these materials the use of multiscale schemes for computational failure evaluations has become a promising topic for evaluating the degradation mechanisms at different scales and to achieve accurate information on the effects of these subscales on the macroscopic response behavior. Among the different multi-scale schemes, those based on homogenization procedures are more commonly used due to their versatility.

For composite materials that are strongly heterogeneous with respect to size and geometry, generally characterized by inclusions or aggregates, it is absolutely necessary to take into account this scale and mesh the inclusions explicitly, since it seriously affects the macroscopic behavior. However, there are standard finite element procedures have limited capabilities to represent heterogeneous mesoscopic structures because of the mesh constraints and unrealistic boundary conditions that distort the resulting numerical solutions.

In this work a new approach is pursued for thermodynamically consistent multiscale analysis [1] of concrete failure behaviour involving mesoscopic RVE. This is based on combining the Virtual Element Method (VEM) [2], [3], [4] and non-linear multiscale analysis. VEM allow discretizations of the domain into arbitrary polygons providing effective and realistic approximations of the aggregates. In the first part of this work, the VEM is outlined, and some details of the proposed meshing procedure are delineated. Then, the multiscale scheme and implementation is explained. Finally, numerical analysis are presented involving stress paths and failure behaviour under different conditions that shows the potential and efficiency of the multiscale approach based on VEM for composite materials.

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