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O. Rokoš, R.H.J. Peerlings, J. Zeman

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eXtended Variational Quasicontinuum Methodology for Lattice Networks with Damage and Crack Propagation

O. Rokoš^{a,*}, R.H.J. Peerlings^b, J. Zeman^{a,c}

^aDepartment of Mechanics, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic.

^bDepartment of Mechanical Engineering, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands.

^cDepartment of Decision-Making Theory, Institute of Information Theory and Automation, Czech Academy of Sciences, Pod Vodárenskou věží 4, 182 08 Prague 8, Czech Republic

Abstract

Lattice networks with dissipative interactions are often employed to analyze materials with discrete micro- or meso-structures, or for a description of heterogeneous materials which can be modelled discretely. They are, however, computationally prohibitive for engineering-scale applications. The (variational) QuasiContinuum (QC) method is a concurrent multiscale approach that reduces their computational cost by fully resolving the (dissipative) lattice network in small regions of interest while coarsening elsewhere. When applied to damageable lattices, moving crack tips can be captured by adaptive mesh refinement schemes, whereas fully-resolved trails in crack wakes can be removed by mesh coarsening. In order to address crack propagation efficiently and accurately, we develop in this contribution the necessary generalizations of the variational QC methodology. First, a suitable definition of crack paths in discrete systems is introduced, which allows for their geometrical representation in terms of the signed distance function. Second, special function enrichments based on the partition of unity concept are adopted, in order to capture kinematics in the wakes of crack tips. Third, a summation rule that reflects the adopted enrichment functions with sufficient degree of accuracy is developed. Finally, as our standpoint is variational, we discuss implications of the mesh refinement and coarsening from an energy-consistency point of view.

^{*}Corresponding author, presently at Department of Mechanical Engineering, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands.

Email address: o.rokos@tue.nl (O. Rokoš)

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