Multi-scale strategy for heterogeneous material with localized failure

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The aim of this contribution is to present an integrated multi-scale strategy \cite{1} well tailored to cope with both highly heterogeneous materials and localized failure. Following \cite{2}, we mean by integrated that micro-scale computations constantly interact with those at the macro-scale. Nevertheless, the proposed method is quite different from the \textsuperscript{2} since local micro computations are not reduced to chosen Gauß point. Indeed, the proposed method takes after the strong coupling algorithm \cite{3}. The key idea is to replace the standard computation of the element tangent matrix and the element residual force for so-called macro elements. This is achieved by two successive condensations of micro operators defined on a finer scale. Localized Lagrange multipliers \cite{4} hook together the two computational levels as depicted on Fig.1

![Image](image-url)

\textbullet: macro-nodes \quad \leftarrow: \text{Lagrange multipliers} \quad \textcircled{•}: micro-nodes

Figure 1: Zoom inside a macro element

The proposed method handles multi-scale analysis with no scale separation. Moreover, the micro computations act as a local kinematic enrichment of the concerned macro elements, which allows us to deal with localized failure mechanism in essentially the same manner as the classical Embedded Discontinuity Finite Element enrichment \cite{5} but with the additional benefit of accounting for true microstructure of heterogeneous material. Both the variational formulation and the solution procedure of the proposed method are discussed. The capabilities of the method are illustrated on a 3D meso-model for heterogeneous quasi-brittle materials \cite{6}.
References


