NON-LOCAL MULTISCALE ANALYSIS METHOD FOR DISCONTINUOUS DEFORMATION OF BRITTLE MATERIALS

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We propose a multi-scale analysis method with non-local damage model in consideration of the discontinuous deformation of heterogeneous microstructures. The two-scale modeling is based on the mathematical homogenization theory [1] and the non-local concept is utilized to evaluate the onset and evolution of macro-scale discontinuities as well as the micro-scale brittle mechanical behavior. The macro-scale damage is identified with the macro-scale localized discontinuities and is assumed to be induced by the failure of periodic microstructures (unit cells) in the framework of homogenization method. A kind of discontinuous deformation analyses (DDA) is employed together with the image-based modeling and is capable of representing the *micro-scale* discontinuous deformation of unit cells. On the other hand, we utilize the capabilities of the finite cover method (FCM) [2], which is one of the generalized analysis methods like X-FEM [3] and GFEM [4], to simulate the *macro-scale* discontinuous deformation. Representative numerical examples are presented to illustrate the performance of the proposed method that can simulate the macro-scale discontinuous deformation caused by the micro-scale brittle failure.

Brittle composite material displays complex fracture characteristics because of the localized damages under the influence of micro-scale heterogeneities. Of course, the two-scale modeling by the homogenization theory is might not be eligible for such macro-scale localization involving weak and strong discontinuities, but seems able to represent the continuous damage or softening of the macro-scale material by distributing the damaged unit cells, until the macro-scale localization takes place. Then, the macro-scale localization is simulated by the macro-scale analyses method apart from the two-scale modeling, once the unit cell loses its structural stability. This micro-scale instability is judged by defining a sort of acoustic tensors that are often appear in phenomenological failure theory. Once the micro-structural instability is evaluated at a macro-scale material point, the points lose the material stability so that the macro-scale cracking takes place. Here, the non-local concept is applied to the evaluation of the macro-scale strain and is expected to play the role of a localization limiter for the cracking analyses. Due to the use of non-local macro-scale strain, the macro-scale structure is endowed with a sort of characteristic material lengths and the numerical results by the two-scale analyses are less dependent on the macro-scale mesh size. Although the modeling strategy and the resulting numerical technique might be mathematically incomplete, the representative numerical examples well demonstrates the influence of micro-scale failure on the macro-scale localization phenomena, which can often be observed in problems in practice.

References

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