11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

OBJECTIVE SIMULATION OF FAILURE BY A SYNERGETIC USAGE OF HYBRID LOCAL/NON-LOCAL CONTINUUM MODEL

Fei Han, Yan Azdoud and Gilles Lubineau

King Abdullah University of Science and Technology (KAUST), Physical Science and Engineering Division, Cohmas Laboratory, Thuwal 23955-6900, Saudi Arabia

Key words: *Damage localization, Fracture, Non-local continuum model, Peridynamics, Coupling method.*

As is now widely accepted, damage localization results in spurious mesh dependancy of finite element computations. If no regularization technique is used, damage localizes into a narrow band whose width depends on the element size and vanishes to zero as the mesh is refined.

A non-local integral theory, so-called Peridynamics [1], has been recently proposed as a way to model the deformation of a continuum, especially for damage and fracture problems [2, 3]. This reformulation of continuum mechanics relies on integral equations rather than on differencial equations. The integral formulation naturally introduces a length scale that avoids any spurious mesh dependancy. Moreover, peridynamics does not require complex criteria to guide the propagation of cracks. Cracks nucleate and grow autonomously, only depending on bond-failure criteria [4]. The peridynamics, however, comes with huge computational cost that makes classical engineering problems out of reach. Also, the peridynamics is characterized by volume-like boundary conditions that can make its application tedious for engineers who are more used to boundary tractions.

In this work, we combined damage mechanics, based on a local constitutive model, and peridynamics theory, with the help of the Morphing technique [5] (which has been introduced for coupling local and non-local continuum models). Then, we proposed an adaptive algorithm from local damage to final rupture. The traditional damage model is used to identify the parts of the structure where cracks will nucleate. Before it reaches localization, the continuum mechanical model is replaced by the peridynamic model in the high damage area. The peridynamic model can then simulate localization and fracture successfully. On the other hand, the local continuum model is still used in the rest of the structure, for reducing computational consumption and adapting to surface force boundary conditions.

This hybrid model successfully deal with damage localization and avoid the spurious mesh sensitivity. It adaptively employ the peridynamic model in local ”key” area, which dramatically reduce computational cost compared with fully non-local model. The method makes possible to predict failures of complex structure.

The validity of this hybrid model is illustrated through an three-dimensional benchmark example.

REFERENCES

[1] S.A. Silling. Reformulation of elasticity theory for discontinuities and long-range forces. *J. Mech. Phys. Solids*, Vol. **48**, 175–209, 2000.

[2] B. Kilic, A. Agwai and E. Madenci. Peridynamic theory for progressive damage prediction in center-cracked composite laminates. *Compos. Struct.*, Vol. **90**, 141–151, 2009.

[3] A. Agwai, I. Guven and E. Madenci. Predicting crack propagation with peridynamics: a comparative study. *Int. J. Fract.* Vol. **171**, 65–78, 2011.

[4] S.A. Silling and E. Askari. A meshfree method based on the peridynamic model of solid mechanics. *Comput. Struct.* Vol. **83**, 1526–1535, 2005.

[5] G. Lubineau, Y. Azdoud, F. Han, C. Rey, A. Askari. A morphing strategy to couple non-local to local continuum mechanic *J. Mech. Phys. Solids.* Vol. **60**, 1088–1102, 2012.