A phase field method for microcracking simulation in concrete microstructure models obtained from microtomography images

Thanh Tung Nguyen*†, Julien Yvonnet*, Michel Bornert†, C. Chateau†, Qhizhi Zhu*

[*] Université Paris-Est Marne-la-Vallée
5 Bd Descartes, 77454 Marne-la-Vallée Cedex 2, France
Email : Julien.yvonnet@univ-paris-est.fr
URL : http://msme.u-pem.fr/equipe-mecanique/meca/yvonnet-julien/

[†] Ecole des Ponts ParisTech,
6,8 avenue Blaise Pascal, 77455 Marne-la-Vallée, France
Email : amen.tognevi@gmail.com

ABSTRACT

In this work, we propose a phase field method for crack nucleation and propagation in highly concrete microstructural models obtained from microtomography images, thus consisting into fine, regular grids of voxels, each converted into a single element. In that context, crack nucleation and propagation is a very challenging problem, due to the discrete description of heterogeneities, and the presence of a very large number of inclusions and pores with arbitrary shapes. To avoid numerical issues related to explicitly describe discontinuities in such models, a phase field method is adopted [1]. An accelerated scheme is proposed by using a modified projection operator for computing the traction/compression split of the strains.

Phase field models for fracture employ a continuous field of variables to describe cracks. The width of the transition zone between cracked and uncracked areas on a small length scale is controlled by a regularization parameter. Phase-field description, based on the Griffith theory [2] of brittle fracture and the variational approach to fracture mechanics proposed by B. Bourdin, et al. (2008) [3], does not require numerical tracking of discontinuities in the displacement field, and allows to greatly reduce computational complexity.

We illustrate the methodology through several numerical examples involving crack nucleation and propagation in microtomography-based concrete models and other complex microstructures in two and three dimensions.

REFERENCES

[1] C. Miehe, M. Hofacker and F. Welschinger. A Phase Field model for rate-independent crack propagation. *Computer Methods in Applied Mechanics*, 199:2765-2778 (2010)

[2] A.A. Griffith, The phenomena of rupture and flow in solids, *Philosophical Transactions of the Royal Society London* A, 221:163-198 (1921)

[3] B. Bourdin, G.A. Francfort, J.J. Marigo, The Variational Approach to Fracture, *Springer Verlag, Berlin,* 2008