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

NUMERICAL MULTISCALE SOLUTION STRATEGY FOR FRACTURING HETEROGENEOUS MATERIALS

Łukasz Kaczmarczyk[1] and Chris J. Pearce[2]

[1] School of Engineering, University of Glasgow, Glasgow, lukasz.kaczmarczyk@glasgow.ac.uk
[2] School of Engineering, University of Glasgow, Glasgow, chris.pearce@glasgow.ac.uk

Key Words: *Multigrid, fracturing, heterogeneous materials, multiscale*

This paper presents a numerical multiscale modelling strategy for simulating fracturing of concrete where the fine-scale heterogeneities are fully resolved. The fine-scale is here modelled using a hybrid-Trefftz stress formulation for modelling propagating cohesive cracks [1]. The very large system of algebraic equations that emerges from detailed resolution of the fine-scale structure, including cracks, requires an efficient iterative solver with a preconditioner that is appropriate for fracturing heterogeneous materials [2]. This presentation presents a two-grid strategy for construction of the preconditioner that utilizes scale transition techniques derived for computational homogenization. This represents an adaptation and extension of the work of Miehe and Bayreuther [3].

For the coarse scale, this paper investigates both classical C0-continuous displacement-based finite elements as well as C1-continuous elements. The preconditioned GMRES Krylov iterative solver utilises a dynamic convergence tolerance, whereby an accurate solution is only required when the Newton method is close to equilibrium. Furthermore, the Newton method is integrated with a local arc-length control technique and line search in order to capture the dissipative load path. In this presentation, the convergence properties and performance of the parallel implementation of the proposed solution strategy is illustrated on a numerical example, demonstrating size effect of the post peak response.

REFERENCES

[1] Kaczmarczyk, L., and Pearce, C.J. (2009). A corotational hybrid-trefftz stress formulation for modelling cohesive cracks. *Computer Methods in Applied Mechanics and Engineering*, 198 (15-16), 1298-1310, 2009.

[2] Kaczmarczyk, L., Pearce, C.J., Bicanic, N., and de Souza Neto, E. Numerical multiscale solution strategy for fracturing heterogeneous. *Computer Methods in Applied Mechanics and Engineering*, 199 (17-20). 1100-1113, 2010.

[3] Miehe, C. and C. G. Bayreuther. On multiscale FE analyses of heterogeneous structures: From homogenization to multigrid solvers. *International Journal for Numerical Methods in Engineering,* 71(10), 1135–1180, 2007.