8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

A MULTISCALE EXTENDED FINITE ELEMENT METHOD FOR CRACK PROPAGATION WITH FRICTIONAL CONTACT

*** P.-A. Guidault[1] and L. Champaney[1]**

[1] LMT-Cachan (ENS Cachan/CNRS/Universite Paris 6/UniverSud Paris)
61 av. du President Wilson, F-94230 Cachan, France
guidault@lmt.ens-cachan.fr

Key Words: *Multiscale strategy, X-FEM, homogenization, LATIN method, crack propagation, frictional contact, macroenrichment.*

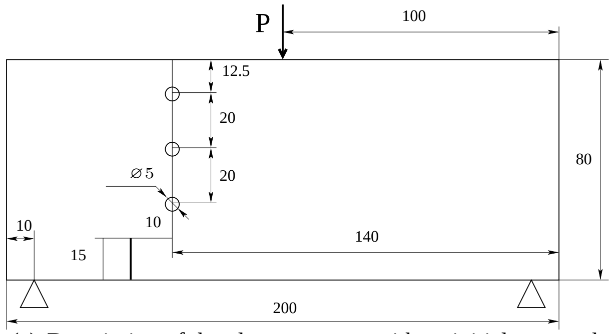
ABSTRACT

Mixed-mode crack growth is affected by frictional contact. For instance, this is typically the case for high-cycle fatigue crack growth in turbine engine components such as blades, fretting fatigue crack growth in rails and wheels or crack growth in geomaterials under a compressive field. Modeling crack growth with frictional contact gives rise to noteworthy challenges for finite element methods. Apart from the classical remeshing difficulties due to the fact that the mesh has to be conformed to the crack's geometry, additional complications arise from the integration of the contact-friction law.

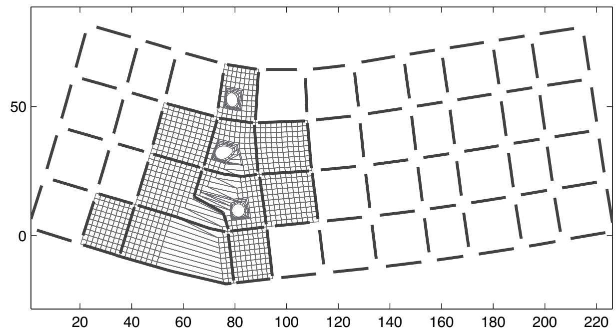
To overcome the meshing difficulties, the X-FEM proved to be particularly suitable [1]. This technique, by enriching the kinematics of continuous media, enables one to introduce discontinuities into the displacement field with only a relatively small number of degrees of freedom. One of the main advantage is that the mesh does not need to conform to the geometry of the crack. In order to integrate the non-linear constitutive law on the interface formed by the crack, a LATIN-based iterative scheme similar to an augmented Lagrangian method was successfully applied in [2]. However, a fine mesh is still required in the vicinity of the crack tip in order to take account of localized phenomena with a sufficient accuracy. Thus, meshing difficulties are partially resolved.

In [4], a Multiscale eXtended Finite Element Method (MS-X-FEM) strategy that enables to use a refined mesh only where it is required without encountering remeshing difficulties was proposed (Fig. 1). It combines two techniques: the micro-macro approach [3] based on a mixed domain decomposition method that makes use of an homogenization technique and the X-FEM to model the crack at the microscale. Since a crack affects both the local level and the global level, different scale separations were studied so that the LATIN-based iterative solver is efficient and the domain decomposition strategy is numerically scalable. It was shown that the introduction of the crack's discontinuity both on the microscale and on the macroscale is advisable and does not deteriorate the convergence rate of the iterative solver when the crack propagates [5].

Only the crack propagation with traction-free condition was addressed in [4,5] but previous works were achieved for contact problems [6,7]. In this presentation, the application of the MS-X-FEM strategy for crack modeling with frictional contact as well as its performances will be presented.



(a) Description of the plate geometry with an initial pre-crack



(b) Deformed shape in the refined substructures (X-FEM) and discontinuous macrodisplacements (thick lines) at the interfaces

Figure 1: Fatigue crack propagation in a plate with three holes computed with MS-X-FEM

REFERENCES

[1] N. Moës, J. Dolbow and T. Belytschko. “A finite element method for crack growth without remeshing”. *Int. J. Numer. Meth. Engng.*, Vol. **46**, 131–150, 1999.

[2] J. Dolbow, N. Moës and T. Belytschko. “An extended finite element method for modeling crack growth with frictional contact”. *Comput. Meth. Appl. Mech. Eng.*, Vol. **190**, 6825–6846, 2001.

[3] P. Ladevèze, 0. Loiseau and D. Dureisseix. “A micro-macro and parallel computational strategy for highly heterogeneous structures”. *Int. J. Numer. Meth. Engng.*, Vol. **52(1-2)**, 121–138, 2001.

[4] P.-A. Guidault, O. Allix, L. Champaney and C. Cornuault. “A multiscale extended finite element method for crack propagation”. *Comput. Meth. Appl. Mech. Eng.*, Vol. **197(5)**, 381–399, 2007.

[5] P.-A. Guidault, O. Allix, L. Champaney and J.-P. Navarro. “A two-scale approach with homogenization for the computation of cracked structures”. *Comput. Struct.*, Vol. **85(17-18)**, 1360–1371, 2007.

[6] L. Champaney, J.-Y. Cognard and P. Ladevèze. “Modular analysis of assemblages of three-dimensional structures with unilateral contact conditions”. *Comput. Struct.*, Vol. **73**, 249–266, 1999.

[7] P. Ladevèze, A. Nouy and O. Loiseau. “A multiscale computational approach for contact problems”. *Comput. Meth. Appl. Mech. Eng.*, Vol. **191**, 4869–4891, 2002.