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

A Global Explicit Residual Based Error Estimator for the eXtended Finite Element Method in *Code_Aster*

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Key Words: *Error estimator, residual, fracture mechanics, XFEM, adaptivity, Code_Aster, industrial applications.*

ABSTRACT

For its engineering related to their plants, Électricité de France develops a computational software Code_Aster[1] based on the finite element method. In the case of computation of industrial cracked structures, the traditional finite element method requires the creation of a mesh that respects the geometry of the crack and a remeshing at each step of the crack propagation. At this time, the creation of 3D meshes for complex structures is extremely expensive and the robustness is not perfect.

The eXtended Finite Element Method (XFEM)[1] provides the possibility to insert, in a finite element mesh, a surface of discontinuity without changing the mesh and this, whatever the crack position. The idea is to enrich the traditional shape functions basis with discontinuous functions. Thus, with the XFEM, many cases (various positions and crack shapes) can be studied on the same mesh. During the crack propagation, the mesh is preserved whereas it must be recreated for each situation with the finite element method. The XFEM has been implemented in Code_Aster with contact taken into account on the crack faces[3].

The accuracy of a finite element approximation is generally evaluated with the methods of discretization error estimation[4,5]. Error estimators are used to locate zones with error in order to use procedures of mesh adaptation to improve and optimize the global quality of a computation for a given criteria (computing time, number of element, etc.). A type of local estimator, known as in quantity of interest or goal oriented[6], provides an error in a zone on a precise mechanical quantity (Von Mises stress, stress intensity factor, etc.).

The alternative presented by XFEM is very attractive from the point of view of mesh management. But to improve results quality, fine meshes are necessary around the crack front. The use of error estimation methods coupled to mesh adaptation procedures becomes necessary.

To estimate the discretization error for XFEM, several estimators were proposed, based on

a smooth strain field[7,8] (like in the Zienkiewicz-Zhu a posteriori error estimator) or the residual[9] (like in the Babuška-Rheinboldt estimator). An estimator based on the residual, developed by Lleras and Hild, has been implemented in Code_Aster. Numerical tests show the good efficiency of the estimator and particularly that the approximate error converges to the exact error. For the simulation of industrial structures, the estimator is used as mesh refinement criteria in an adaptive process, driven by HOMARD[10], a 3D mesh refinement and coarsening software developed by Électricité de France. We will try to develop a mesh optimality criteria that minimize the number of elements for a given accuracy. Our final goal is to develop and to implement in Code_Aster, a goal-oriented residual based error estimator following the ideas developed by Delmas *et al.*[11].

REFERENCES

[1] *Code_Aster*, Open source finite element code, web site: www.code-aster.org/

[2] N. Moës, J. Dolbow, T. Belytschko, "A finite element method for cracked growth without remeshing", *Int. J. Numer. Meth. Engng.*, **46**, 131-150, (1999)

[3] S. Géniaut, "Approche X-FEM pour la fissuration sous contact des structures industrielles", *Doctoral thesis*, Ecole Centrale de Nantes, (2006)

[4] I. Babuška and W.C. Rheinboldt, "A posteriori error estimates for the finite element method", *Int. J. Numer. Meth. Engng.*, **12**, 1597-1659, (1978).

[5] O.C. Zienkiewicz, J.Z. Zhu, "A simple error estimator and adaptive procedure for practical engineering analysis", *Int. J. Numer. Meth. Engng.*, **24**, 337-357, (1987).

[6] S. Prudhomme, J.T. Oden, "On goal-oriented error estimation for elliptic problems : Application to the control of pointwise errors", *Comput. Methods Appl. Mech. Engng.*, **176**, 313-331, (1999).

[7] S. Bordas, M. Duflot, "Derivative recovery and a posteriori error estimation in extended finite element methods" *Comput. Methods Appl. Mech. Engng.*, **196**, 3381-3399, (2007).

[8] J.J Ródenas, E. Giner, J.E. Tarancón, O.A. González, "A recovery type error estimator for the extended finite element method based on a singular+smooth stress field splitting", *Int. J. Numer. Meth. Engng.*, submitted, (2007).

[9] V. Lleras, P. Hild, "Estimateurs d'erreur pour la méthode XFEM", *Proc. Colloque National en Calcul des Structures*, **vol. 2**, 49-54, Giens, France, (2007).

[10] HOMARD®, a 2D and 3D mesh refinement and coarsening software, web site: www.code-aster.org/outils/homard/

[11] J. Delmas, P. Coorevits, P.-B. Badel, M. Guessasma, "An explicit estimator for goal-oriented h-adaptivity with mesh optimality criteria", *Proc. International Conference of Adaptive Modeling and Simulation*, 93-96, Göteborg, Sweden, (2007).