

Ribeaucourt, R.; Baietto-Dubourg, M.-C.; Gravouil, A.

A new fatigue frictional contact crack propagation model with the coupled X-FEM/LATIN method. (English) [Zbl 1173.74385](#)

Comput. Methods Appl. Mech. Eng. 196, No. 33-34, 3230-3247 (2007).

Summary: A fatigue crack model addressing frictional contact along crack faces and multi-axial non-proportional solicitations is proposed. In this respect, an X-FEM numerical model coupled with unilateral contact with friction is presented within the linear elastic fracture mechanics framework (LEFM). Hysteresis effects are addressed through an incremental formulation. Furthermore, a modified LATIN iterative solver and a local convergence indicator adapted for the frictional contact problem are proposed. It ensures the local convergence of the normal and tangential problems independently. A generalized expression for the J -integral under frictional contact conditions is derived. In the same way, a path-independent domain interaction integral is implemented in order to extract the mode I and mode II stress intensity factors. The crack propagation direction is predicted according to Hourlier's criterion adapted to multi-axial non-proportional solicitations. Crack growth predictions are presented for three fatigue crack lengths under rolling contact loading. Stress intensity factors (SIF) are computed and the crack growth direction is determined. These numerical results agree quantitatively with previous results obtained according to a reference model.

MSC:

[74R10](#) Brittle fracture

[74M15](#) Contact in solid mechanics

[74M10](#) Friction in solid mechanics

[74S05](#) Finite element methods applied to problems in solid mechanics

Cited in **20** Documents

Keywords:

[frictional contact](#); [rolling contact fatigue](#); [fatigue crack growth](#); [X-FEM](#); [LATIN method](#)

Full Text: [DOI](#)

References:

- [1] T.T. Dang, Étude de la fatigue de contact de roulement, IUT Angoulême, Rapport de DEA, 2003.
- [2] Benuzzi, D.; Bormetti, E.; Donzella, G., Stress intensity factor range and propagation mode of surface cracks under rolling – sliding contact, *Theor. appl. fract. mech.*, 40, 55-74, (2003)
- [3] Belytschko, T.; Black, T., Elastic crack growth in finite elements with minimal remeshing, *Int. J. numer. methods engrg.*, 45, 601-620, (1999) · [Zbl 0943.74061](#)
- [4] Moës, N.; Dolbow, J.; Belytschko, T., A finite element method for crack growth without remeshing, *Int. J. numer. methods engrg.*, 46, 131-150, (1999) · [Zbl 0955.74066](#)
- [5] Sukumar, N.; Moës, N.; Moran, B.; Belytschko, T., Extended finite element method for three-dimensional crack modelling, *Int. J. numer. methods engrg.*, 48, 1549-1570, (1999) · [Zbl 0963.74067](#)
- [6] Moes, N.; Gravouil, A.; Belytschko, T., Non-planar 3D crack growth by the extended finite element and level sets – part I/II, *Int. J. numer. methods engrg.*, 53, 11, 2549-2586, (2002) · [Zbl 1169.74621](#)
- [7] Ferrie, E.; Buffiere, J.Y.; Ludwig, W.; Gravouil, A.; Edwards, L., Three-dimensional study for fatigue crack propagation of a semi-elliptical crack: 3D crack visualization using X-ray microtomography and numerical simulation of crack propagation using the extended finite element method, *Acta mater.*, 54, 44, 1111-1122, (2006)
- [8] Rethore, J.; Gravouil, A.; Combescure, A., An energy-conserving scheme for dynamic crack growth using the extended finite element method, *Int. J. numer. methods engrg.*, 63, 631-659, (2005) · [Zbl 1122.74519](#)
- [9] Prabel, B.; Combescure, A.; Gravouil, A.; Marie, S., Level set X-FEM non-matching meshes: application to dynamic crack propagation in elastic – plastic media, *Int. J. numer. methods engrg.*, 69, 1553-1569, (2007) · [Zbl 1194.74465](#)
- [10] T. Elguedj, A. Gravouil, A. Combescure, A mixed Augmented Lagrangian eXtended Finite Element Method for modelling elastic – plastic fatigue crack growth with frictional contact, *Int. J. Numer. Methods Engrg.*, in press. · [Zbl 1194.74387](#)
- [11] Elguedj, T.; Gravouil, A.; Combescure, A., Appropriate extended functions for X-FEM simulation of plastic fracture mechanics, *Comp. methods appl. mech. engrg.*, 195, 7-8, 501-515, (2006) · [Zbl 1222.74041](#)

- [12] Melenk, J.M.; Babuska, I., The partition of unity finite element method: basic theory and applications, *Comp. methods appl. mech. engrg.*, 139, 289-314, (1996) · [Zbl 0881.65099](#)
- [13] Dolbow, J.; Moës, N.; Belytschko, T., An extended finite element method for modeling crack growth with frictional contact, *Comp. methods appl. mech. engrg.*, 190, 6825-6846, (2000) · [Zbl 1033.74042](#)
- [14] S. Geniaut, *Approche X-FEM pour la fissuration sous contact des structures industrielles*, PhD Thesis Ecole Centrale de Nantes, France, 2006.
- [15] R. Ribeaucourt, *Gestion du contact avec frottement le long des faces de fissures dans le cadre de la methode X-FEM, Application a la fatigue tribologique*, PhD Thesis INSA de LYON, France, 2006.
- [16] Dubourg, M.-C.; Lamack, V., A predictive rolling contact fatigue crack growth model: onset of branching, direction, and growth – role of dry and lubricated conditions on crack patterns, *ASME J. tribol.*, 124, 4, 680-688, (2002)
- [17] Baietto-Dubourg, M.-C.; Chateauminois, A.; Villechaise, B., In situ analysis and modeling of crack initiation and propagation within fretting contacts using polymer materials, *Tribol. int.*, 36, 2, 109-119, (2003), (Special issue)
- [18] Lamacq, V.; Dubourg, M.-C.; Vincent, L., A theoretical model for the prediction of initial crack angles and sites of fretting fatigue cracks, *Tribol. int.*, 30, 391-400, (1997)
- [19] Lamacq, V.; Dubourg, M.-C., Modelling of initial fatigue crack growth and crack branching conditions under fretting conditions, *Fatigue fract. engrg. mater. stru.*, 22, 535-542, (1999)
- [20] M.-C. Dubourg, V. Lamacq, Stage II crack propagation direction under fretting fatigue loading. A new approach in accordance with experimental observations, in: D.W. Hoepfner, V. Chandrasekar, C.B. Elliott (eds.), *Symposium Fretting Fatigue Current Technology and Practices*, ASTM STP 1367, held in Salt Lake City, 2000, pp. 463-450.
- [21] Dai, D.N.; Hills, D.A.; Nowell, D., Modelling of growth of three-dimensional cracks by a continuous distribution of dislocation loops, *Comput. mech.*, 19, 538-544, (1997) · [Zbl 1031.74520](#)
- [22] G. Duvaut, J.L. Lions, *Les inéquations en mécanique et en physique*, Dunod, 1972. · [Zbl 0298.73001](#)
- [23] Daux, C.; Moës, N.; Dolbow, J.; Sukumar, N.; Belytschko, T., Arbitrary branched and intersecting cracks with the extended finite element method, *Int. J. numer. methods engrg.*, 48, 1741-1760, (2000) · [Zbl 0989.74066](#)
- [24] Ladevèze, P., *Notes: sur une famille d'algorithmes en Mécanique des structures*, *Compte rendu de l'académie des sciences de Paris*, 300 serie 2, 2, 41-44, (1985) · [Zbl 0597.73089](#)
- [25] Ladevèze, P., *Nonlinear computational structural mechanics*, (1998), Springer New York
- [26] L. Champaney, *Une nouvelle approche modulaire pour l'analyse d'assemblages de structures tridimensionnelles*, ENS Cachan, Thèse de doctorat, 1996.
- [27] Palmer, A.C.; Rice, J.R., The growth of slip surfaces in the progressive failure of over consolidated Clay, *Proc. roy. soc. lond. ser. A math.*, A332, 527-548, (1973) · [Zbl 0273.73059](#)
- [28] Yau, J.F.; Wang, S.S.; Corten, H.T., A mixed-mode crack analysis of isotropic solids using conservation laws of elasticity, *J. appl. mech.*, 47, 335-341, (1980) · [Zbl 0463.73103](#)
- [29] Shih, C.F.; Asaro, R.J., Elastic – plastic analysis of cracks on biomaterial interfaces, part I: small scale yielding, *J. appl. mech.*, 55, 299-316, (1988)
- [30] Gosz, M.; Dolbow, J.; Moran, B., Domain integral formulation for stress intensity factor computation along curved three-dimensional interface cracks, *Int. J. solids struct.*, 35, 15, 1763-1783, (1998) · [Zbl 0936.74057](#)
- [31] Nakamura, T.; Parks, D.M., Antisymmetrical 3D stress field near the crack front of a thin elastic plate, *Int. J. solids struct.*, 25, 12, 1411-1426, (1989)
- [32] Nakamura, T., Three-dimensional stress fields of elastic interface cracks, *J. appl. mech.*, 58, 939-946, (1991)
- [33] Moran, B.; Shih, C.F., Crack tip and associated domain integrals from momentum and energy balance, *Engrg. fract. mech.*, 27, 6, 615-642, (1987)
- [34] Li, F.Z.; Shih, C.F.; Needleman, A., A comparison of methods for calculating energy release rates, *Engrg. fract. mech.*, 21, 2, 405-421, (1985)
- [35] Shih, C.F.; Moran, B.; Nakamura, T., Energy release rate along a three-dimensional crack front in a thermally stressed body, *Int. J. fract.*, 30, 79-102, (1986)
- [36] *Integrated Study of Rolling Contact Fatigue*, ICON CIG Funded Supported Research Project, Task 3, University of Sheffield, Final Report, June 1999.
- [37] Bold, P.E.; Brown, M.W.; Allen, R.J., A review of fatigue crack growth in steels under mixed-mode I and II loading, *Fatigue fract. engrg.*, 15, 965-977, (1992)
- [38] M. Truchon, M. Amestoy, *Etude théorique et expérimentale de la fissuration par fatigue sous sollicitations bi axiales*, Institut de recherche de la sidérurgie française -IRSID, Rapport de recherche, November 1981.
- [39] F. Hourlier, H. D'Hondt, M. Truchon, A. Pineau, *Fatigue crack path behavior under polymodal fatigue*, IRSID, Rapport de recherche, November 1982, RE 958.
- [40] H. D'Hondt, *Etude du branchement des fissures de fatigue sous sollicitations bimodales non proportionnelles, Influence de la cinétique de propagation du matériau*, IRSID, Rapport de recherche, December 1982, PE 3459.
- [41] Amestoy, M.; Bui, H.D.; Dang-Van, K., Déviation infinitésimale d'une fissure dans une direction arbitraire, *J. appl. mech.*, 289B, 99-102, (1979)

This reference list is based on information provided by the publisher or from digital mathematics libraries. Its items are heuristically matched to zbMATH identifiers and may contain data conversion errors. It attempts to reflect the references listed in the original

paper as accurately as possible without claiming the completeness or perfect precision of the matching.