Associative quasistatic delamination model based on energetic solutions and its BEM implementation

C.G. Panagiotopoulos[1], **V. Mantič**[1], **T. Roubíček**[2,3]

[1]Group of Elasticity and Strength of Materials, Department of Continuum Mechanics, School of Engineering, University of Seville, Camino de los Descubrimientos s/n, Sevilla 41092, Spain

[2]Mathematical Institute, Charles University, Sokolovská 83, CZ-186 75 Praha 8, Czech Republic

[3]Institute of Thermomechanics of the ASCR, Dolejškova 5, CZ-182 00 Praha 8, Czech Republic

cpanagiotopoulos@us.es, mantic@esi.us.es, roubicek@karlin.mff.cuni.cz

Abstract

The problem of quasistatic rate-independent evolution for problems of elastic-brittle delamination is considered. Delamination processes for linear elastic bodies glued by an adhesive to each other or to a rigid outer boundary are studied. The energy amounts dissipated in fracture Mode I (opening) and Mode II (shearing) at the interfaces are distinguished [1, 2], an inelastic process at these interfaces being devised in such a way that the dissipated energy depends only on the rates of internal parameters and therefore the model is associative.

An internal variable having the meaning of the plastic tangential slip along the interface is introduced and an elastoplastic-type model with kinematic-type hardening devised. Additionally to an interface plasticity, a damage along the interfaces is taken into account introducing a damage variable [3] which may take values in the range between unity and zero, with the value of unity standing for the non damaged state while that of zero for the totally damaged state. Solutions are defined within the context of the so-called energetic solutions [4, 5, 6].

After introducing a time discretization pattern a boundary discretization is considered and the boundary element method [7] is utilized to solve the respective boundary value problems for subdomains and compute the stored elastic energy.

A few sample problems, solved by an in–house code [8], are studied in order to illustrate the capabilities of the numerical method developed.

References

[1] Roubíček, T., Kružík M., Zeman J., Delamination and adhesive contact models and their mathematical analysis and numerical treatment. In: Mathematical Methods and Models in Composites, Mantič V. (Ed.), Imperial College Press, London, 2012.

[2] Roubíček, T., Mantič, V., Panagiotopoulos, C.G., Quasistatic mixed-mode delamination model, (2011), Disc. Cont. Dynam. Syst. - S. (submitted)

[3] Frémond, M., Non-Smooth Thermomechanics, Springer-Verlag, Berlin, 2002.

[4] Mielke, A., Theil, F., On rate-independent hysteresis models, Nonl. Diff. Eqns. Appl. (NoDEA), 11(2004) 151–189.

[5] Mielke, A., Theil, F., Levitas, V. I., A variational formulation of rate–independent phase transformations using an extremum principle, Arch. Rational Mech. Anal., 162(2002) 137–177.

[6] Mielke, A., Evolution in rate-independent systems, (Ch. 6) In: Handbook of Differential Equations, Evol. Equations, Vol. 2, Dafermos C.M., Feireisl E. (Eds.), Elsevier, Amsterdam, 2005, pp.461–559.

[7] París, F., Cañas, J., Boundary Element Method, Fundamentals and Applications, Oxford University Press, Oxford, 1997.

[8] Panagiotopoulos, C.G., Open BEM Project, `http://www.openbemproject.org/`, 2010.