Application of Configurational Mechanics to crack propagation

Laura Crusat* and Ignacio Carol

* ETSECCPB (School of Civil Engineering)
Universidad Politècnica de Catalunya (UPC)
08034 Barcelona, Spain
e-mail: laura.crusat@upc.edu, ignacio.carol@upc.edu

ABSTRACT

Crack initiation and propagation is an essential aspect in the mechanical behavior of a large variety of materials and structures in all fields of Engineering and, in particular, the prediction of crack trajectories is one of the major challenges of existing numerical methods. Classical procedures to fix crack direction have been based on local criteria such as maximum (tensile) hope stress. However, Fracture Mechanics principles suggest that global criteria should be used instead, such as maximizing structural energy release rates. An emerging trend along this way is based on Configurational Mechanics, which describes a dual version of the mechanical problem in terms of configurational pseudo-stresses, pseudo-forces, etc. all with a physical meaning related to the change in global structural elastic energy caused by changes in the structural geometry (configuration) [1].

In the FEM context, these concepts are applied to optimize energy density with respect to reference coordinates using the discrete configurational forces. Configurational stresses given by Eshelby´s energy-momentum tensor [2] may be integrated using standard expressions to give configurational nodal forces. Adequate treatment of these forces in the context of iterative FE calculations, may lead to prediction of crack trajectories in terms of global structural energy.

In the paper, the basic concepts of configurational mechanics are outlined, as well as the procedures to implement them in a standard FE formulation. The numerical implementation is verified with some basic academic examples, such as the three point bending test of a simply supported notched beam or other similar simple cases [3]. The results show the advantages and also limitations of the application of Configurational Mechanics to predict crack propagation paths in otherwise elastic materials.

REFERENCES

[1] P. Steinmann, M. Scherer, and R. Denzer, "Secret and joy of configurational mechanics: From foundations in continuum mechanics to applications in computational mechanics" *ZAMM-Journal of Applied Mathematics and Mechanics*, **89**, 614-630 (2009).

[2] J.D. Eshelby, "The elastic energy-momentum tensor" *Journal of Elasticity* **5.3-4,** 321-335 (1975).

[3] C. Miehe, and E. Gürses. "A robust algorithm for configurational-force-driven brittle crack propagation with R-adaptive mesh alignment." *International Journal for Numerical Methods in Engineering* **72.2**, 127-155 (2007).