Plasticity and fracture: a variational model based on a diffuse cohesive energy

G. Del Piero[1], G. Lancioni[2] and R. March[3]

[1]Dipartimento di Ingegneria, Università di Ferrara, Via Saragat 1, 44100 Ferrara, Italy
E-mail: dlpgpt@unife.it

[2]Dipartimento di Architettura, Costruzioni e Strutture, Università Politecnica delle Marche,
Via Brecce Bianche 1, 60131 Ancona, Italy
E-mail: g.lancioni@univpm.it

[3]Istituto per le Applicazioni del Calcolo, CNR, Viale del Policlinico 137, 00161 Roma, Italy
E-mail: riccardo.march@gmail.com

ABSTRACT

In this communication, which anticipates the main results of the work in progress [1], a unified variational approach to plasticity and fracture is proposed. In the model, the energy functional is the sum of an elastic bulk energy, an inelastic cohesive energy, and a quadratic gradient term. The inelastic energy, instead of being concentrated on singular surfaces of discontinuity for the displacement field, as usual in the theories of fracture, is diffused on the volume. On a similar assumption is based the damage model proposed in [2], obtained by regularizing, in the sense of Γ-convergence, the Griffith energy functional. The difference is that in the present model the energy is assumed to be the sum of two distinct parts, one purelly elastic and one dissipative which depends on the inelastic part of the deformation. In this way, the model succeeds in predicting an evolution of the inelastic deformation of the type commonly described in Plasticity. Depending on the shape of the cohesive energy function and on the size of the body, three different kinds of behaviors can be observed: strain localization, inelastic diffuse deformation and rupture.

The one-dimensional incremental problem of a bar subjected to a tensile loading is solved by means of a FEM algorithm. The numerical results make evident the influence of the shape of the cohesive energy density on the mechanical response. For example, a concave cohesive energy produces a strain softening response, with strain localization followed by brittle fracture. A convex energy produces strain hardening and diffuse inelastic deformation. In particular, it is shown that an energy assumed to be concave, then convex for larger deformations and finally again concave is able to predict the two-step rupture mechanism observed in polymers and in the stress-strain diagram of steel bars.

REFERENCES

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