New developments in modeling interfaces by the Strong Discontinuity Approach

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Nuovi sviluppi nella modellazione di interfacce tramite il metodo delle discontinuit forti

ABSTRACT

The paper deals with a variational formulation of the equilibrium problem for a continuum Ω characterized by an elastic behaviour, in which the growth of interfaces S takes places. This phenomena can be effectively described by means of models that incorporate the kinematics of strong discontinuities obtained by an enrichment of the displacement field with a discontinuous term. The proposed formulation falls in the context of the Strong Discontinuities Approach [1, 2, 3], implemented by means of Elements with Embedded Discontinuities [4].

The growth or the activation of an interface is ruled by a specific activation function, based on a cohesive fracture like criterion. In the general formulation the medium and the interface are ruled by different constitutive equations, defined by distinct free energy and dissipation functionals. The strong form of the equilibrium and compatibility conditions is presented, with special attention to the equilibrium conditions at the interfaces. The obtained weak formulation allows an effective numerical implementation of the interface model, able to predict both the occurrence of the discontinuity and its direction; no tracking algorithm is introduced.

Among the many possible algorithmic frameworks, the one recently proposed in [5], based on the formal analogy between the enriched continuum and the theory of classical plasticity, has been implemented. The starting point of the weak formulation is a mixed multi-fields Hu-Washizu functional Π^{HW}.

The general formulation is obtained discretizing the displacement fields appearing in Π^{HW} and resolving the internal variables at constitutive level. Differently from the classical equations of Statical Kinematical Optimal Nonsymmetric formulation, a symmetrical form of the tangent constitutive operator, and consequently of the tangent stiffness matrix, is derived. [6]

References

[1] J. Simo, J. Oliver and F. Armero. An analysis of strong discontinuities induced by strain softening in rate independent inelastic solids. *Computat. Mech.*, **12**, 277–296, 1993.

[2] J. Oliver, M. Cervera and O. Manzoli. Strong discontinuities and continuum plasticity models: The strong discontinuity approach. *Int.J. Plasticity*, **15**, 319–351, 1999.

[3] L. Contrafatto and M Cuomo. Finite element implementation of an enhanced strong discontinuities approach formulation vs. smeared crack models. In *Proceedings of IV European Conference on Computational Mechanics - WCCM 2010*, Paris, France, 2010. full text on CD ROM.

[4] M. Jirásek and T. Zimmermann. Embedded crack model: Part i: Basic formulation. *Int. J. Num. Meth. Eng.*, **50**, 1269–1290, 2001.

[5] J. Mosler. A novel algorithmic framework for the numerical implementation of locally embedded strong discontinuities. *Comp. Meth. App. Mech. Eng.*, **194**, 4731–4757, 2005.

[6] L. Contrafatto and M. Cuomo. Elastic-plastic damaging behaviour of concrete: a generalised Ottosen criterion. In *Proceedings of the VII International Conference on Computational Plasticity COMPLAS 2003*, E. Oñate and D. R. J. Owen, editorsCIMNE, Barcelona, Spain, 2003. full text on CD ROM.