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Università degli Studi di Pavia

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in collaboration with
Centro di Simulazione Numerica Avanzata – CeSNA
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SEMINAR

Finite Elements with Embedded Discontinuities for the Modeling of Failure in Solids

The failure of solids and structures is often characterized by the appearance of discontinuous solutions of the mechanical boundary value problem, like the discontinuous displacements (or the so-called strong discontinuities) associated with cracks in brittle materials or with multi-scale treatments of shear bands and other localization bands in ductile failures. This situation has motivated the formulation of different techniques for the numerical resolution of these solutions. We present in this seminar several recent advances in the formulation of the so-called finite elements with embedded strong discontinuities. Exploiting the aforementioned multi-scale setting, these elements incorporate the kinematics of these highly non-smooth solutions through enhancements that are handled entirely at the element level, preserving the overall structure of the standard global mechanical/structural problem, and thus leading to efficient techniques for the numerical simulation of these failures in solids.
Specifically we discuss the formulation of finite elements incorporating high-order interpolations of the displacement jumps along the discontinuity, in both the infinitesimal and finite deformation ranges. In particular, we present three-dimensional brick elements that we are currently developing in this framework. A main result of the proposed strategy for the strain enhancement is the resolution of the kinematics of the strong discontinuities without the characteristic overstiff response (or stress locking) that other alternatives may lead to. This strategy consists in the incorporation of the separation modes in the discrete strain field of the element, rather than the definition of a local discontinuous displacement field. A major advantage of this approach is the ability to extend it to highly complex situations, like the patterns involved in the branching of the discontinuities. After a discussion of these theoretical and practical (implementation) aspects for the new 3D elements, we present a series of representative numerical simulations illustrating the performance of the finite elements, including a summary of similar developments in other settings (e.g. plane/antiplane problems, beams, plates,...). We consider applications including failure in quasi-brittle materials (concrete), delamination in composites, and ductile failures of elastoplastic solids in the quasi-static and dynamic ranges, the latter involving ductile/brittle mode transitions.

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MS1 Conference Room,
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