Stress-based least-squares FEM for Elastoplasticity

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For the discretization of the variational inequalities modelling elastoplastic material behaviour, a constrained first-order system least squares formulation is proposed and investigated. This approach allows the simultaneously finite element approximation of displacement and stresses, in the Sobolev spaces H^1 and $H(\mathrm{div})$, respectively. The coercivity of the underlying bilinear form is proved under suitable assumptions on the hardening laws for a plastic flow rule of von Mises type. Our formulation is momentum-conservative in an element-wise fashion and does not degenerate for (nearly) incompressible materials. This is even true if piecewise affine continuous functions (for the displacement components) are combined with lowest-order Raviart-Thomas elements (for the rows of the stress tensor). A semi-smooth Gauß-Newton method is set up based on the Newton derivative for the solution of the arising non-smooth nonlinear problems. Finally, computational results for common benchmark examples are shown including experiments for the limiting case of perfect plasticity.

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