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Non-linear analysis of quasi-brittle materials through a FEM-VEM approach

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Abstract

Among the computational strategies able to simulate crack propagation in solids, discrete crack models introduce a strong or weak discontinuity along the inter-element boundaries or inside the elements. The Augmented-FEM strategy (A-FEM) separates an element in two standard finite elements and a nonlinear interface where discontinuities localize. An advancement of A-FEM was proposed in [1] and consisted in the use of a zero-thickness interphase model (IPH) in place of the interface (ZTI), adding internal stresses and strains to the contact ones. Unlike ZTI models, IPH does not require a specific traction-displacement jump constitutive law and the constitutive laws adopted for IPH can correspond to those of bulk material.
In this work a new crack tracking algorithm is proposed, in a continuous FEM – discontinuous VEM description. VEM [2] is more flexible than standard FEM, since the element can be a polygon characterized by any number of edges, without constraints. The process starts with a discretization of the domain using standard FEM. Localization criteria and the spectral analysis of the fracture tensor built at the element level identify those elements crossed by a crack and crack orientation, respectively. Localized elements are then grouped to align localization bands into unique cracks, based on simple heuristic criteria. Substructures are therefore created, composed of virtual elements and IPHs representing discontinuities. At the global level, equilibrium is iteratively achieved by considering internal forces from substructures. These are solved in a VEM framework by imposing, as essential boundary conditions, displacements at nodes shared with the rest of the structure. Because the original element could be divided into very distorted sub-elements or non-standard elements, the VEM is more performant than the FEM. The main features of the adopted strategy are illustrated through benchmark examples.

References

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