A PUFEM FOR COHESIVE ZONE MODELING OF FRACTURE

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Computational modeling of localization, and in particular fracture, continues to be a challenging area of research. In the context of the finite element method (FEM), cohesive zone idealizations have been used to model progressive failure including the case where the size of the process zone is significant. Cohesive zone models idealize the kinematics of the localization with a strong displacement discontinuity and then relate these displacement jumps to their work conjugate interfacial tractions. While the approach can yield mesh objective results, introduction of the surface of discontinuity into the finite element mesh is problematic unless the crack path is known *a priori*. Approaches to this geometric problem range from initially including interface elements along all element edges to using adaptive mesh refinement to insert interface elements "on the fly." One recent approach has been to exploit the partition of unity properties of the FEM displacement approximation, introducing enrichment in the displacement field – the partition of unity FEM (PUFEM) [1].

A PUFEM for modeling fracture with cohesive zones is under development. Unlike previous PUFEM formulations addressing cohesive zone modeling (see *e.g.*, [2], [3] and [4]), the displacement field is enriched in the neighborhood of the crack tip with series terms from an analytical solution for a cohesive zone in a two-dimensional elastic domain. With the proposed enrichment functions the formulation thus has the potential to model responses that would require very fine meshes to capture with simpler enrichment functions; *i.e.*, the proposed approach may have more of a multi-scale nature.

This work began at the Army Research Laboratory and was initially motivated by the need for mesh-objective modeling of localizations in armors and penetrators. A more recent motivating problem is the failure of hardened and deeply buried targets. Preliminary results are thus for a model problem that represents 1 m x 1 m of concrete (plane stress), subjected to "combined bending and axial loading." These initial results are limited to mode-I fracture, linear softening, and a uniform mesh.

Comparisons with a fine-scale FE model that contains a predefined localization surface indicate that the method has promise. Even with a coarse PUFEM mesh the displacement fields are qualitatively comparable to the fine-scale results. PUFEM prediction of the cohesive zone propagation compares well with fine-scale results until there are too few elements in the cracked section to model the "global response." While the tip propagates incrementally across each element, the accuracy is greatest when the tip is near an element edge. Comparisons with a skewed PUFEM mesh are in progress.

References

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