Mixed Finite Element Modeling of Quasi-Brittle Cracks Under Cyclic Loading

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ABSTRACT

There is general agreement that the standard FE formulation is inadequate for solving cracking problems because it produces spurious mesh-dependent results in terms of the computed crack paths.

Mixed strain/displacement finite elements have been recently re-examined by the authors to address this problem [1-2]. Mixed finite elements have certified to produce results without spurious mesh-bias and predict more accurately crack trajectories in a determining way. They have shown to provide much more reliable computations of the structural response, damage pattern, force-displacement curves and collapse mechanism of structures subjected to monotonic loading.

Taking advantage of their superior performance, an extension to model cracking in brittle materials subjected to cyclic loading using mixed finite elements is presented. For this, an enhanced version of the finite element program COMET [3] has been developed. Several damage constitutive laws are introduced to model microcrack closure-reopening (MCR) effects, as well as tensile and compressive damage and irreversible strains.

The feasibility and performance of the method is extensively assessed through numerical benchmarks and comparison with experimental evidence. The model is able of accurately simulating the phenomena related to cracking in brittle materials subjected to cyclic loading. It can evaluate stiffness recovery in the force-displacement curves. It can also capture the closure and reopening of multiple cracks in the computed body, as well as consider intersecting cracks in the failure mechanisms with any angle. Spurious mesh dependency is avoided without the need of crack tracking techniques or other computational schemes that alter the continuum mechanical problem.

REFERENCES

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