A COHESIVE FINITE ELEMENT METHOD FOR COMBINED DETERMINISTIC AND STOCHASTIC ANALYSES OF MICROSCOPIC DYNAMIC FRACTURE

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Variations in constituent properties, phase morphology, and phase distribution cause deformation and failure at the microstructural level to be inherently stochastic. Deterministic analyses do not characterize the range of outcome in terms of quantities such as energy dissipation, crack initiation time and failure resistance. It is important to characterize the degree of variation of material response and its dependence on microstructural uncertainties. In this research, the focus is on the influence of material property variations on fracture processes in two-phase ceramic microstructures under dynamic loading. The framework of analysis integrates the second order perturbation method for stochastic processes and the cohesive finite element method (CFEM). Explicit account of random crack development and arbitrary microstructural morphologies is obtained. This combination of determinism and stochasticity is achieved by introducing stochastic variability to material properties over their expected values through the perturbation analysis and by requiring the satisfaction of all field equations. This represents an application of a stochastic method to micromechanics for explicit failure analysis with random constitutive properties. Calculations characterize the range of energy dissipation, energy release rate, crack initiation time and crack lengths for given variations of constitutive properties in an Al_2O_3/TiB_2 ceramic composite system. It is seen that the effect of variation of interfacial properties on the range of variation of fracture outcome is more significant than the effect of the variation of bulk properties. Additionally, an increase in the level of variation of interfacial properties results in an unproportional and asymmetrical increase in the range of variation of failure outcomes. Variations in material properties manifest in the form of the crack path variation and a tendency of cracks to follow the weakest path in a microstructure. Simulations using different microstructures show that a strong dependence of fracture outcome on phase morphology and phase size.