Geometrically exact integral-based nonlocal model of ductile damage: basic properties and numerical treatment

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ABSTRACT

We develop the integral approach [1] for the analysis of nonlocal ductile damage in metals. The starting point is the previously proposed phenomenological model of finite strain plasticity [2]. The original damage model is delocalized by the averaging operator [1], applied to damage-related quantities like porosity and continuity. Depending on the implemented delocalization procedure, at least one internal length parameter in introduced into the formulation. As a result, the damage localization is controlled by the presence of length-like parameters, thus regularizing the boundary value problem. Owing to the regularization, numerically robust and physically sound simulations of crack initiation and propagation are possible. Unphysical localization of strain and damage into a zero thickness layer is effectively prevented. From the theoretical standpoint, the basic properties of the new material model are analysed. Model's thermodynamic consistency, objectivity, and w-invariance [3] are established. Efficient numerical algorithms are proposed. To test the robustness of the integral-based approach, low-order meshless smoothed particle simulations are carried out. As a demonstration problem, we simulate crack initiation and propagation in a compact tension specimen. The resulting force-displacement curves, apparent fracture toughness, energy dissipation, and patterns of damage distribution provide insight into the mechanical phenomena, captured by the framework. The impact of the modelling assumptions on the predicted structural strength is clarified: Isotropic and anisotropic averaging is discussed; the delocalization is applied on various configurations; continuity is introduced as a dual damage variable to minimize the unrealistic diffusion of damage.

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REFERENCES

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