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# Lifetime Prediction with a Damage Model Based on Mixed-Mode Microcrack Propagation

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The derivation of a damage model for brittle damage by growth of micro-cracks is shown. First a finite deformation framework is presented. This framework is based on the multiplicative decomposition of the deformation gradient in an elastically recoverable part and a damage part whose energy is dissipated. No plastic part is present, since in brittle damage no macroscopic plastic strains occur. The micro-plasticity at the crack tip leads only to very small macroscopic plastic strains, so that it is assumed, that for vanishing stresses, no deformation remains. This approach introduces, similar to finite plasticity, three different configurations, but with different physical meaning. The reference configuration is the undamaged configuration, which is connected to the damaged intermediate configuration by the damage mapping. The actual configuration is then reached with the help of the elastic mapping. So the undamaged intermediate configuration works for the macroscopic observable process as a reference with changing properties. With the help of this framework, the damaged tensor of elastic moduli can be obtained with the help of push and pull operation, as the elasticity tensor of the damaged intermediate configuration. The evolution equation for the damage deformation follows from a micro-mechanical approach of growing mixed-mode microcracks in a unit cell, which show kinking of the crack path. The crack growth is based on the variational principle of a body containing a crack, resulting in the maximum energy release rate principle for growing 2D or 3D cracks. As the simulation of a growing mixed mode crack per integration point would lead to a numerical expensive Method, a replacement crack approach is developed. With the help of this, the infinitesimal kinked crack is replaced by a straight crack with different orientation, resulting in the same energy dissipation. Finally the transition from the microscopic to the macroscopic framework is performed by a thermodynamical consistent homogenization procedure, which is based on the equivalence of the energy dissipated in crack growth and damage evolution. A finite element implementation of this model is used to predict the lifetime of model problems under cyclic loading conditions.

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