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A continuum damage mechanics model for static and fatigue degradation of fiber reinforced polymers

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Objective of the present study is the definition and implementation of a fatigue damage model for short fiber reinforced composites. The model is based on a linear elastic or viscoelastic base model. The base model is enhanced by introducing a damage variable acting on the Young's and shear moduli respectively. Failure of the material is assumed to be described by a Tsai-Hill type failure envelope. Based on experimental observations on the creep response of a short glass fiber reinforced polyamide 6 material, the criterion is re-written to a strain space formulation rather than the original stress space formulation. The damage evolution is assumed to be driven by the approach of a state point in strain space towards the failure envelope. Assuming that the fatigue response can be approximated by a linear representation of the S-N curve in a double logarithmic representation, a power-law formulation is derived for the damage evolution equation. The model is implemented as a user defined material subroutine into a commercial finite element program. Subsequently, the procedure is validated against an experimental data base on an injection molded short glass fiber reinforced polyamide 6 material. The data base comprises experiments on standard laboratory specimens loaded in static, fatigue and creep modes as well as more general specimens introducing general multiaxial loading scenarios. The model proves to provide accurate failure predictions under both proportional and cyclic loading.