ANISOTROPIC DAMAGE OF HIGHER ORDER CONTINUUM MODELS FOR CELLULAR MATERIALS

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ABSTRACT

We present an extended continuum-mechanical model for the description of the deformation behavior of foam-like structures including anisotropic damage. While it is very difficult to formulate constitutive equations on the macroscale for these materials, the constitutive equations, material parameters and evolution equations including damage are assumed to be known for the beam-like microstructure, which is modeled by Timoshenko beam elements. The standard continuum theory is not able to represent boundary layer effects, which can result from the restricted rotational degrees of freedom of the beam elements on the boundaries. Therefore, the standard continuum theory is not sufficient for the description of the macroscopic behavior. While the Timoshenko beam theory can be obtained by a dimensional reduction of the Cosserat theory, on the macroscale the Cosserat theory is chosen. Within a finite element computation the strains and, according to the kinematically extended macroscopic model, the curvatures are mapped to the integration point. Attaching a representative microstructure to each integration point of the macroscopic FE calculation allows for the construction of a local boundary value problem (bvp) for the microstructure, whereby each beam of the microstructure possesses an independent damage variable. According to the anisotropic representative microstructure, e. g. a honeycomb structure, macroscopic anisotropy is included in the formulation in a natural way. After solving the microscopic bvp, the forces and moments are mapped back to the macroscale by a homogenization procedure yielding the stress and couple stress response, respectively. This approach is known from literature as FE^2 model. We get a regularized macroscopic solution due to the inclusion of an internal length scale by homogenization of the microscopic local model. The capability of the model is shown in various numerical examples by biaxial loading of the structure demonstrating the anisotropic macroscopic behavior in dependency of the considered microstructure.