Damage simulation of linear thermo-chemo-elastic fibre reinforced composites using mean-field homogenization methods

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ABSTRACT

A mean-field homogenization framework for constitutive multiscale (meso-macro) modelling including material failure of three distinct linear thermo-chemo-elastic material phases is presented in this work. Within this framework it is possible to compute the macroscopic mechanical behaviour of fibre reinforced materials based on the constitutive models of the constituents. The three phases are unidirectional fibres surrounded by an interface, which is surrounded by a matrix material. Different mean-field homogenization methods are used to determine the effective properties for example the Mori-Tanaka scheme [3], the self-consistent method [2] and the interaction direct derivative [4], a more recently published method. For homogenization of the three phase composite we use the two-level recursive scheme from [1]. The fibre and interface is regarded as a two-phase composite which, once homogenized, plays the role of a homogeneous inclusion for the matrix material. A distinction is made between four different failure modes namely matrix failure, fibre failure, matrix-fibre interface failure and a simultaneous failure of the matrix and the fibre called matrix-fibre failure. For matrix failure a critical yield stress is decisive within the matrix. The fibre failure is caused by a high normal stress in direction of the fibre. The shear stress between the fibre and matrix is responsible for the matrix-fibre interface failure. To simulate a crack growth, we used our own implemented element deletion routine. Representative examples demonstrates the different types of failure and the resulting crack growth in a fibre reinforced material. Figure 1 shows the macro von Mises stress and the damage variable of the interface during crack propagation

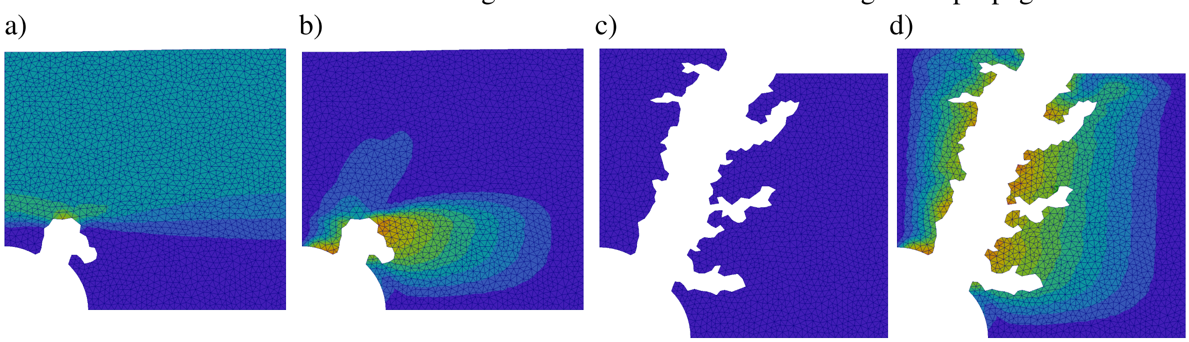

Figure 1: Crack propagation for two time steps: a) macro von Mieses stress, b) interface damage variable, c) macro von Mises stress after structure failure, d) interface damage variable after structure failure.

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