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PREDICTING THE RISK OF FAILURE OF THIN FIBER NETWORKS – A STOCHASTIC MULTISCALE APPROACH

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Materials are characterized by a certain degree of randomness in their mechanical response. This is true for all materials but especially pronounced in disordered materials such as thin fiber-networks [1]. This randomness can be seen as one of the main reasons for unexplained occasional failures that cannot be predicted by deterministic material models [2]. The rapid development of characterization tools enabled the possibility to quantify randomness at different scales. Ideally, the stochastic variability in the microstructure should be propagated to the macromechanical level using direct numerical simulations of the fiber network. However, such simulations of large fiber networks are characterized by overwhelming computational costs. Herein, a continuum approach is developed based on stochastic volume elements (SVE) and the spatial fields of the uniaxial strength and strain to failure in the network. The methodology is described by the following steps: i) An SVE-size is chosen and SVE size-specific constitutive law parameters are determined, ii) spatial fields of strength and strain to failure in the fiber network are constructed for the chosen SVE size iii) the two spatial fields are mapped to a spatial field of constitutive response using the proposed constitutive model. The approach is validated by reconstructing fiber networks and studying their uniaxial mechanical response. The results show good agreement between the proposed continuum model and direct numerical simulation with respect to the strength of the network. This work suggests that it is sufficient to simulate random spatial fields of strain and strength to failure, in conjunction with the proposed constitutive model, in order to construct a continuum model realization of a thin fiber network.

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