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TOWARDS POST-CRITICAL MULTI-SCALE MODELING OF DAMAGE IN BIOLOGICAL FIBROUS TISSUES

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Abstract. Material rupture in soft biological tissues is normally caused by micro-mechanical failure mechanisms. As a great number of biological fibrous tissues feature a network of collagen fibres as its main load-bearing constituent at small scales, strain localisation due to progressive damage progression in these fibres is the main cause of nucleation of macro-scale cracks. Based on a novel RVE-based and strain-driven multi-scale formulation (F. Rocha et.al., *CMAME*, 341:740–787 (2018)), with especially suited boundary conditions to tackle localisation in fibre networks, the critical point is determined through the spectral analysis of the acoustic homogenised tensor. As it is well-known in the field of continuum mechanics, after this point the problem becomes ill-posed and some numerical strategy to circumvent the size-effects is necessary. In continua, this issue is successfully addressed by means of a number of strategies, as for example smeared-crack approach, gradient and non-locality of damage models, however in discrete network-like materials a consistent methodology, up to authors' knowledge, is lacking. In this work, we present a strategy based on the smeared-crack approach to regularise the damage evolution law in each single fibre and after the critical point has been detected, a selective insertion procedure (strain-insertion) of the opening-rate vector is employed. Finally, numerical examples showing the suitability of the present methodology are shown in a number of RVEs settings and load-cases, where the objectivity is considered in terms of the fracture energy released by the RVE homogenised response.