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INSTABILITY ANALYSIS OF POROUS MICRO-CELLS IN MULTISCALE MODELLING OF DUCTILE FAILURE

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Abstract. A general failure oriented RVE-based multi-scale formulation has been proposed in the past by the authors. The formulation deals with the objectivity issue of the homogenized response in terms of the micro-cell size. This issue is a main topic of analysis when RVE-based multi-scale techniques are used in the context of strain localization problems. The model has been applied to simulate quasi-brittle fracture problems. Our goal here is to generalize the model to account for large deformation ductile failure mechanisms at the smaller length scales. A continuum percolated matrix, accounting for growth and coalescence of micro voids, is considered and defined in terms of a hardening elasto-plastic material. As a first step, the model mechanical behaviour is analysed when it is subjected to loads close to the macro-scale instability point and subsequent degradation process. The goal is twofold: (i) to postulate a general criterion to detect the point where macro-scale objectivity is lost and (ii) to define a micro-scale sub-domain where strain localizes, i.e. a specific zone of the RVE that will be used to homogenize the stress field, after the instability detection and according with the previous multiscale procedure of the authors. The proposed methodology to get such objectives consists of a multiscale simulation utilizing several micro-cells, with different characteristic sizes. These cells are generated by repetition of a one-pore unit cell. The analyses for all these cells are performed until reaching the homogenized stress response separation (such response separation means that the model size-objectivity is lost). The criterion for detecting this singular point is compared with alternative failure criteria, for example: (i) the Rice's bifurcation analysis based on the homogenized tangent constitutive tensor and (ii) alternative pore coalescence techniques available in the literature (due to necking process between adjacent voids). Once the instability, or bifurcation, point at the macroscopic level has been established, the micro-scale mechanical state is evaluated in detail in order to gain additional insight about the complex phenomenology of ductile failure.