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A MODEL TO REPRESENT DUCTILE FRACTURE AT LOW STRESS TRIAXIALITY

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Ductile fracture at high triaxiality regime is well-known to be controlled by void nucleation, growth and coalescence. However, under low stress triaxiality condition and general three dimensional finite deformation, fracture is still poorly predicted due to the complex loading state and microstructural changes under such a condition. Experimental evidence reveals not only void growth, but also important void rotation under shear-dominated loading (see e.g. [1]). The ability of ductile damage models to predict both void growth and void rotation is thus crucial for complex loading applications.

In the present study, the constitutive model for elasto-plastic porous materials developed in [2] is employed. This model is based on a rigorous homogenization method, which can capture the evolution of microstructure of porous materials, represented by the void volume fraction, the aspect ratios and the orientations of general ellipsoidal voids. In addition, loading direction is not necessary aligned with ellipsoidal voids axes. The model is first implemented in an object-oriented finite element (FE) software ([3]). Furthermore, since numerical results depend strongly on FE mesh when softening is involved, a non-local formulation is developed. The implemented model is then used to study ductile fracture of porous materials for different loading configurations. Fig. 1 shows the transformation of an initial spherical void subjected to two different loadings: biaxial tension (with different strain magnitudes in two loading directions - b) and combined shear and biaxial tension (c). In the first case, the void changes from a sphere into a general ellipsoid, whereas void rotation can be observed in the second case. These two void transformations cannot be predicted by the well-known GTN model ([4]).

Different validation tests have been carried out to study the behavior of general ellipsoidal voids under various loading configurations. The model seems promising to predict ductile fracture for complex loadings, involving both void growth and void rotation mechanisms.

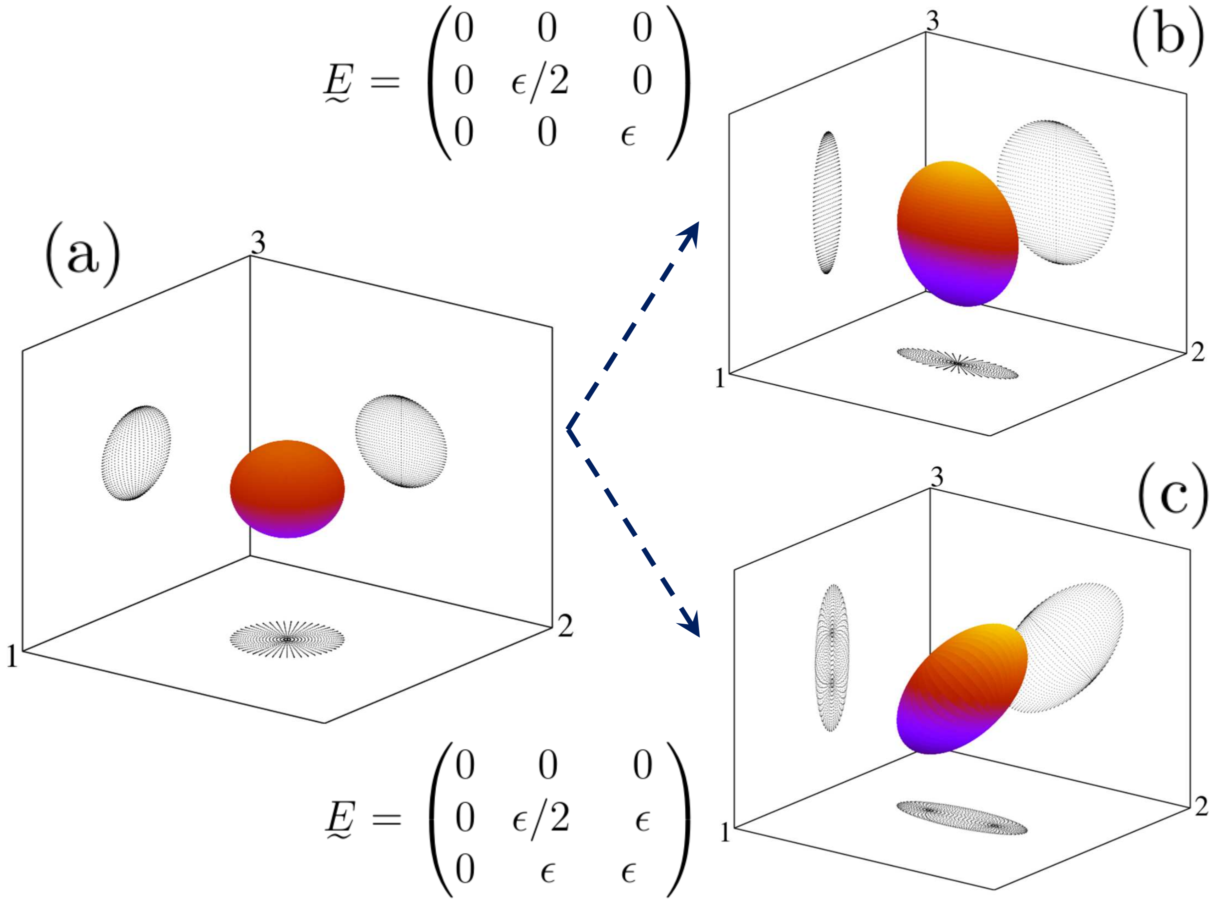

Figure 1: Evolution of an initial spherical void under biaxial tension and combined shear and biaxial tension loadings: (a) initial void; (b) void under biaxial tension; and (c) void under combined biaxial tension and shear loading. Voids are presented by their projections on three orthogonal planes in the Cartesian frame.

REFERENCES

[1] M. Achouri, G. Germain, P. Dal Santo, and D. Saidane. Experimental characterization and numerical modeling of micromechanical damage under different stress states. *Materials & Design* , 50(0):207 – 222, 2013.

[2] K. Danas and N. Aravas. Numerical modeling of elasto-plastic porous materials with void shape effects at finite deformations. *Composites Part B: Engineering*, 43(6):2544 – 2559, 2012.

[3] J. Besson and R. Foerch. Large scale object-oriented finite element code design. *Computer Methods in Applied Mechanics and Engineering*, 142(1–2):165 – 187, 1997.

[4] V. Tvergaard and A. Needleman. Analysis of the cup-cone fracture in a round tensile bar. *Acta Metallurgica*, 32(1):157 – 169, 1984.