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COMPUTATIONAL HOMOGENIZATION OF INCOMPRESSIBLE MICROSTRUCTURES

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A challenging problem in computational homogenization occurs in conjunction with macroscopic incompressibility. Such a situation is encountered when the micro-constituents of a composite are intrinsically incompressible, e.g. incompressible inclusions in an incompressible matrix, which infers macroscale incompressibility as well. Another scenario is that an initially compressible macroscale response becomes incompressible as the result of the deformation process. An important example is the evolving porous microstructure of a powder metallurgy product during the process of sintering, whereby the effective response is compressible until the porosity vanishes. This process is thus characterized by a transition from the compressible to incompressible regimes that should be handled within a unified variational framework, c.f. [1].

In this contribution we show how to derive the system of macro- and micro-scale equations to deal with macroscopic incompressibility. The macroscale problem is represented by a mixed variational formulation (displacement and pressure), where the deviatoric stress and the volumetric strain are obtained through homogenization on a Representative Volume Element (RVE). The microscale problem is also represented in a mixed format; however, the subscale displacement and pressure fields are complemented with Lagrange multipliers that are associated with the choice of boundary conditions. The role of the classical boundary conditions on the RVE (Periodicity, Dirichlet, and Neumann) is discussed.

Examples of the new homogenization scheme are shown for intrinsically incompressible elasticity. In particular, emphasis is put on the bounds on the effective properties that can be derived by suitable combinations of the Dirichlet and Neumann boundary conditions on the RVE.

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