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A Finite Deformation Analysis of Cellular Solids

Many natural or man-made cellular materials are flexible, pliable structures, which resist plastic damage and fracture, and the material recovers completely after large deformations. In order to gain new insight into the mechanical behaviour of these omnipresent materials, we analyse and compute the deformation of seamless cellular bodies within the framework of finite strain elasticity, which in principle can provide a complete description of elastic responses of the solid cell walls under loading.

Specifically, for hyperelastic materials, boundary value problems in statics are often equivalent to variational problems, which provide powerful methods for obtaining approximate solutions, and they can also be used to generate finite element methods. However, for cellular structures with 'free' elastic cell walls, determining the mechanical behaviour under external loading can be difficult, and requires the application of adequate mathematical models and methods.

Assuming that the cell walls are hyperelastic, we develop a qualitative analysis scheme which enables us to carry out meaningful comparisons between the model structures and the solid material from which they were made when subject to the two fundamental deformations which form the basis for all other deformations, namely extension and compression.