Higher-order continuum modelling of size effects in cellular solids

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The mechanical properties of cellular materials depend strongly on the specimen size to the cell size ratio. Experimental studies show that under uniaxial compression and bending, the stiffness and strength of these materials fall below the corresponding bulk value when the ratio of the specimen size to the cell size is small. Conversely, in case of simple shear and indentation, the overall elastic and plastic properties rise above the bulk value when the specimen size and indenter size is decreased. One way to account for these size effects is to explicitly model the discrete cellular microstructure. These models will be shown to give a good agreement with the experiments and yield valuable insight on the dominant cellular deformation mechanisms that are responsible for the observed size-effects. To capture the microscale-level deformation at the macroscopic scale, one can use higher-order continuum theories (such as Cosserat theory or Mindlin's strain gradient theory). In this work we explore the performance of these theories through a careful comparison with discrete simulations for a number of boundary value problems.