"The Mechanics of Multi-Phase Lattices"

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Traditionally, lattice materials comprise a micro-architectured lattice and intervening porosity. The mechanical properties are sensitive to the topology, relative density and the length scale, but usually much less sensitive to the degree of imperfection. But what if we fill the porosity with an inviscid, incompressible fluid? The resulting mechanical properties are sensitive to the degree to which fluid can leak from one cell into the next. The macroscopic in-plane yield surface of a hexagonal honeycomb, filled with an inviscid, incompressible fluid, has been calculated and analytical models have been obtained for the collapse modes. Numerical simulations reveal that the finite strain response is sensitive to the angle of inclination of the hexagonal cells, and to the possibility of cavitation within the liquid core. If cavitation is absent, the compressive response can display shear localisation along an inclined band (reminiscent of fibre microbuckling in composites). Alternatively, if cavitation is present, mild localisation occurs into inclined bands with unit cells that first dilate and then crush until volumetric lock-up occurs and a residual shear state exists within the band. A Maxwell-line construction can be used on the unit cell response in order to determine the steady state propagation stress for both the case of no-cavitation and cavitation. Other competing collapse modes exist that exhibit strong softening but do not admit the existence of a localisation (shear) band. If time permits, some remarks will be made on the fracture of filled lattices, and on the actuation of a lattice due to induced swelling by the intercalation of a liquid phase or by Li ions.