The deformation mechanisms of fibre-network materials

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Abstract

Fibre-network materials/structures widely exist, examples include the fibrous paper, the micro-sized extracellular matrix and the nano-sized cytoskeletal fibre networks of cells. Based on simplified periodic geometrical model [1, 2], we performed dimensional analyses and obtained the in-plane and out-of-plane Young's moduli and yield strengths as functions of the relative density ρ of the fibre network materials, the Young's modulus E_S and the yield strength σ_{ys} of the solid material. It is found that the in-plane Young's E_x of the fibre network materials is approximately proportional to $\rho^4 E_s$ if the relative density is small, and gradually becomes proportional to ρE_s with the increase of the relative density. In contrast, the out-of-plane Young's modulus E_z of the fibre network materials is always approximately proportional to $\rho^5 E_s$ if the relative density is smaller than 0.2. It is also found that the in-plane yield strength of the fibre network materials is proportional to $\rho^2 \sigma_{ys}$ and the out-of-plane yield strength is proportional to $\rho^3 \sigma_{ys}$, which are significantly different from the typical hexagonal honeycombs. The analytical results show perfect agreement with the computer simulation results obtained from periodic random fibre network models and the experimentally measured results from metal fibre sintered sheets [3].

Keywords: Fibrous materials, Elastic properties, Yield strength, Fibre network model.

References

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