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A Young-Laplace equation based finite element method to study surface effects on mechanical behaviour of nanomaterials

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Abstract

The significant rise in the strength and stiffness of porous materials at nanoscale has been widely observed in experiments. Theoretical researches on the effective Young's modulus of such materials by taking into account surface effect with particular microcellular architecture have successfully predicted the increasing of effective Young's modulus as the characteristic size shrink to ~100nm.To overcome the strict restriction of analytical solution on the microstructure, a new numerical scheme is proposed. This method iteratively analysis the deformed surface of the model to obtain the principle curvature which will be used to get the additional cross interface normal load descripted by generalized Yong-Laplace equation. The additional load will then be applied on the surface of the model as a non-uniform distributed load. Simulation result of fixed-fixed beam with this scheme presents a good agreement with theoretical prediction. Results from more general cases with complex topologies, successfully predicted the surge of effective Young's modulus and compares well to experiment data.