Effect of minimal defects in periodic cellular solids

Abstract

We study the relationship between the geometry of a point defect and the spatial distribution of the strain energy in an otherwise regular two-dimensional cellular solid. Sites of concentrated strain energy are potential sites for failure initiation in the cellular solid. For simplicity, a hexagonal honeycomb structure is chosen for our analysis. In our description, the basic building block of the honeycomb is not a beam, but rather a three-armed ‘‘joint’’, with the three beams meeting at a junction point. A minimal defect is introduced in an otherwise regular hexagonal honeycomb by exchanging one joint of the regular honeycomb with a joint of varying geometry. Finite element methods and micromechanical models are used to calculate the spatial distribution of the strain energy density (SED). Two different scenarios are found depending on the external loading. For hydrostatic loading, the SED is concentrated in the defect. Uniaxial loading resulted in intricate distribution of the SED, with ist highest values not in the defect but in the nearer environment of the defect. The study demonstrates the complexity of SED patterns occurring around defects, which change their characteristics depending on the loading conditions.