DYNAMIC CRUSHING OF TWO-DIMENSIONAL CELLULAR SOLIDS WITH IRREGULAR CELL SHAPES AND NON-UNIFORM CELL WALL THICKNESS

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A number of micromechanics models have been developed to simulate dynamic crushing behaviors of perfectly-ordered cellular solids (foams) using finite element (FE) methods (e.g., [1, 2]). Despite their simplicity and good predictability, these models are limited by their inability to account for microstructural imperfections inherent in most real cellular materials, whose cell structures are typically non-periodic, non-uniform, and disordered (e.g, [3, 4]). Hence, more advanced random models are needed to obtain improved predictions. The objective of the current study is to provide such a micromechanics model. The new model simultaneously incorporates two types of imperfections commonly present in two-dimensional (2-D) cellular solids (i.e., irregular cell shapes and non-uniform cell wall thickness) and extends the static model developed in [3] to dynamic crushing.

The Voronoi tessellation technique is utilized in this study to construct the honeycomb models for FE analyses. Perturbations are introduced to a regular packing of nuclei to generate a Voronoi diagram with different degrees of irregularity (amplitude a), and to the uniform thickness of the established Voronoi diagram to generate a uniform distribution of wall thickness with different degrees of non-uniformity (amplitude b). Five FE models are built using the Voronoi diagrams for five honeycomb samples with the same pair of a and b to assess the varying trends and scattering of the force-displacement relations. Each model (diagram) contains several hundreds of cells. Simulation results reveal that an increase of impact velocity substantially increases the plateau force value, while cell shape irregularity has an insignificant effect on the force.

References

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