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Modeling of internal contact in cellular solids and reticulated structures for simulation of collapse, crushing and densification

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ABSTRACT

Cellular solids, metal foams, and reticulated structures are used for a variety of applications, such as light-weight construction, impact absorption, acoustics, heat transfer, etc. Some of these applications involve very large deformations of the foam material that can cause the internal voids in the microstructure of these materials to collapse leading to contact and densification. Similar behavior is also observed in the collapse of light-weight reticulated structures. In order to study such processes, one needs a detailed model for capturing internal contact within the microstructure to evaluate its effect on global properties of the structure. In this study, we develop a simplified model for simulation of open-cell foams and reticulated structures using one-dimensional elasto-plastic elements to represent individual ligaments in the microstructure of the foam or elements in a reticulated structure. In order to model internal contact during collapse and crushing of cellular solids, the computational model was enhanced with the capability to detect and resolve contact between elements using an augmented Lagrangian method in an energy-based approach. The formulation for capturing contact was modified to allow for smooth transitions between various contact pairs. Numerical issues with the detections, resolution and smoothing of contact to facilitate convergence will be presented. This approach was used to study several benchmark problems and its performance was evaluated by comparing the solutions with existing studies both in terms of errors and computational cost.