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Finite element analysis of the compressive and shear responses of structural foams using computed tomography

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Abstract

This paper aim to establish a framework for finite element modelling of the compressive and shear responses of closed-cell foams using computed tomography images, and to explore the deformation and failure mechanisms at cell level in closed-cell foams under compression and shear. Results show that quadratic tetrahedral mesh is more suited than cubic voxel mesh in modelling closed-cell foams. The mesh density with one quadratic tetrahedral element across the thickness of cell walls can yield results with good accuracy. Representative volume elements for closed-cell foams need contain at least 5.2 cells and 3.9 cells along each edge for compression and shear tests, respectively. Compressive buckling and shear buckling appear during the initial elastic regime of compression and shear, respectively. Buckling acts as a failure initiator, which changes the deformation modes of cell walls from in-plane compression, tension or shear to bending. Subsequent large deflection of cell walls and material yielding lead to further degradation in the global stiffness of foams. Shear buckling causes cell walls to lose load-carrying capacity along the direction of the compressive component of the shear load, therefore is less detrimental than compressive buckling in reducing the load-bearing capacity of cell walls. Consequently, the global stiffness of closed-cell foams degrades less rapidly in shear tests compared to compression tests. The Young's modulus of foam base materials slightly affects foam strengths. This is because cell walls undergo bending after buckling, and the maximum bending load that the buckled cell walls can bear is determined by the yield strength of base materials.

Keywords: Finite element model; Computed tomography; Closed-cell foams; Compression and shear; Failure mechanism; Buckling and yielding.

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