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A Statistical Mechanics Theory of Random Honeycomb and Open-Cell Foam Structures

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Honeycombs and foams are examples of advanced engineering materials with random structures. Because of structural randomness, the internal force distribution in these materials due to external loadings would not be uniform, yet existing failure criteria of these structures are derived from mean-field considerations in which the structural randomness is not explicitly taken into account. In this work, finite element simulations are used to investigate the force distributions in stressed random honeycomb and open-cell foam structures. A statistical-mechanics-based theory is also presented to describe the force distributions. The key in this theory is the use of an entropy functional, analogous to the Shannon entropy in Information Theory, to describe the structural randomness. The theory predicts the internal force distributions to be Gaussian for hydrostatic or pure shear loading, and convolutions of Gaussian functions for other load mixities. Agreement with finite element results is excellent.

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