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Lattice Structures and Strength Optimization

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Following traditional topology optimization approaches, under most loading and boundary conditions the ideal material distribution within the optimization domain takes the form of a lattice structure. These types of structures arise regardless of the way the optimization problem is posed [1][2] or whether mass, stress, or stiffness [3][4] are used as the objective in the formulation. Within these lattices lie structures with varying local thicknesses at different points within the domain. It is well known that for certain material groups, such as quasi-brittle solids, strength is dependent on a structural length scale. Often strength increases with decreasing size (fracture mechanics regime) and for small characteristic sizes saturates (strength regime). However, other strength-size relationships are indeed possible in various materials. As an example, we have demonstrated that a strength maximum exists at intermediate dimensions for 3D printed Polyjet polymer parts. We pose the hypothesis that strength-based topology optimization outcomes which utilize size dependent strength criterion as a quantity of interest in the optimization formulation shall differ from those which use constant strength models. We will demonstrate an implementation of framework for topology optimization which incorporates a strength-size criterion, consider traditional [5] and novel strength size effects for 3D printed quasi-brittle materials, and discuss the implications to the realization of such structures.

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