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DESIGNING ELASTOMERIC 3D PRINTED ARCHITECTURES WITH A MECHANICAL REDUCED ORDER MODEL

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Abstract: Direct ink writing of silicone elastomers enables printing with precise control of porosity and mechanical properties of ordered cellular solids, suitable for shock absorption and stress mitigation applications. With the ability to manipulate structure and feedstock stiffness, the design space becomes challenging to parse to obtain a solution for a desired non-linear mechanical response. Here we derive an analytical design approach a subset of architectures. Results from finite element simulations and quasi-static mechanical tests of two different parallel strand architectures were analyzed to understand the structure-property relationships under uniaxial compression. Combining effective stiffness-density scaling with least squares optimization of the stress responses yielded general response curves parameterized by resin modulus and strand spacing. An analytical expression of these curves serves as a reduced order model, which, when optimized, provides a rapid design capability for filament-based 3D printed structures. To demonstrate the capability, we present computed optimal architecture designs that satisfy prescribed loading conditions and porosity constraints along with mechanical characterization data to provide validation.

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