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Design and Performance of Periodic Trusses

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Design and Performance of Periodic Trusses

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KEYWORDS:
Buckling, truss design

Additive manufacturing has enabled fabrication of weight-efficient periodic trusses over a wide range of length scales. Most recently, it has opened new possibilities of multi-material structures. The present talk will address issues associated with design and performance of truss structures [1]. The focus will be on truss failure, through strut buckling, yielding or brittle fracture. Examples will be drawn from studies on effects of circular nodal fillets on node stiffness, strut buckling and stress concentrations (Figure 1) [2, 3]. The work includes experimental measurements of axial and bending strut strains and nodal rotations under uniaxial compressive loading of trusses along with corresponding finite element simulations (Figures 2 and 3). Effects of free boundaries and manufacturing defects on failure initial and progression are also addressed. The talk will also explore some emerging concepts in multi-material trusses, with the goal of tailoring the elastic/plastic response under large strains.

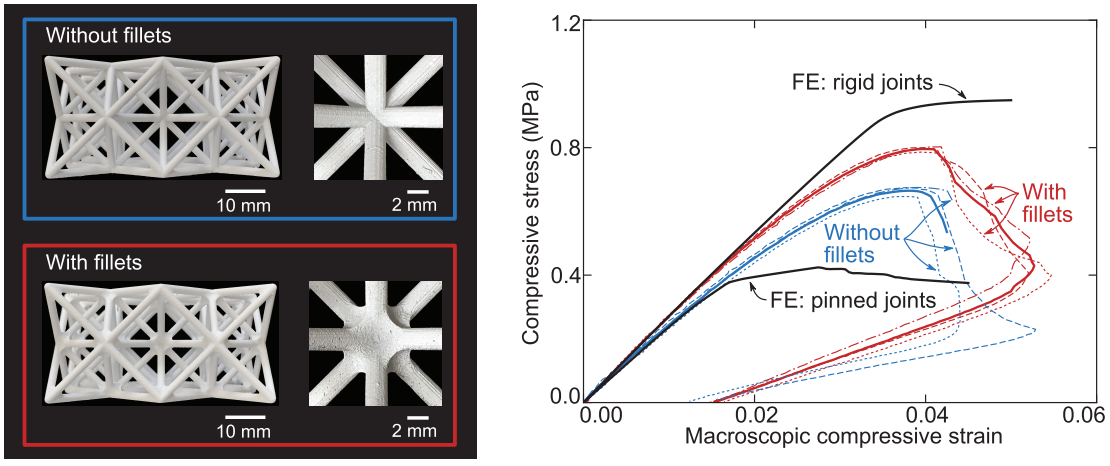

Figure 1: Experimental measurements on compressive response of an octet truss made by stereolithography, showing beneficial effects of finite nodal fillets. (a) Pristine trusses with and without fillets. (b) Compressive response from experiments and finite element simulations.

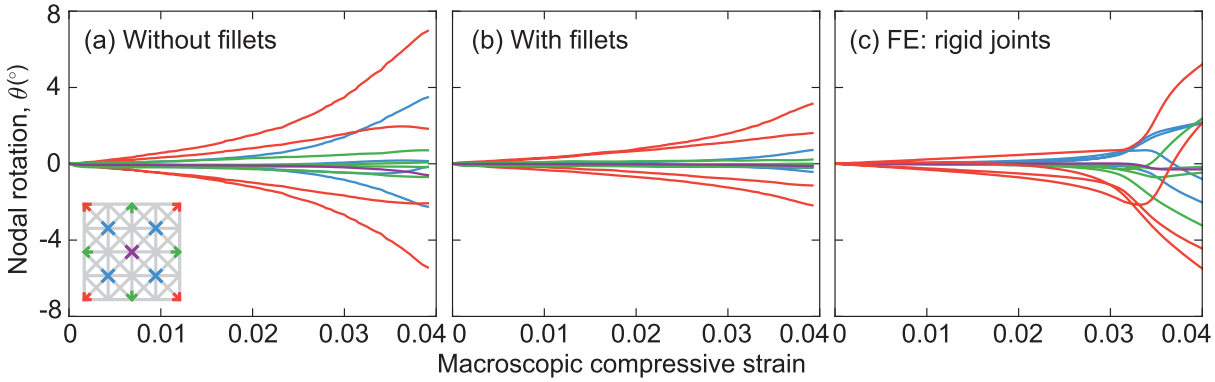

Figure 2: (a, b) Nodal rotations on the external faces in the trusses with and without fillets at their respective peak stresses and (c) those obtained from rigid-node FE calculations. Line colors correspond to node colors in the inset in (a).

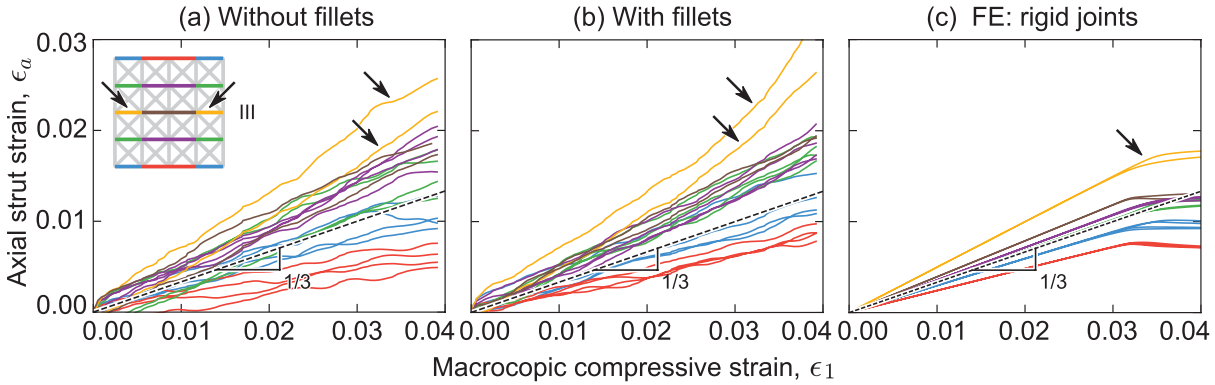

Figure 3: Evolution of measured axial strains in struts that experience tension when the truss is loaded in compression (axially): (a) without and (b) with fillets. (c) Finite element simulations reveal similar dependencies of strut strains with strut locations. Dotted lines (with slopes of 1/3) represent analytic predictions for periodic boundary conditions and infinitesimal nodes. Arrows indicate struts that experience the greatest axial strain and are the ones that rupture first. Here the maximum tensile strut strain is about 50% greater than the nominal value expected of an infinite truss.

References

[1] Zok, F.W., Latture, R.M., Begley, M.R, Periodic truss structures. *Journal of Mechanics and Physics of Solids*, **96** (2016) 184-203.

[2] Latture, R.M., Begley, M.R., Zok, F.W., Design and mechanical properties of elastically-isotropic trusses. *Journal of Materials Research,* DOI: 10.1557/jmr.2018.2 (2018).

[3] Latture, R.M., Rodriguez, R.X., Holmes, L.R., Zok, F.W., Effects of nodal fillets and external boundaries on compressive response of an octet truss. *Acta Materialia*, in press (2018)