Basket Weaving Provides Remarkable Stiffness and Resilience for Functional Structures

Guowei (wayne) Tu[1] and Evgueni Filipov*[1]

[1]University of Michigan [Ann Arbor] – United States

Abstract

The craft of basket weaving has been used since antiquity to interweave thin fibers into sophisticated 3D geometries that retain their shape to serve as storage containers or other functional structures. In this talk, we explore the unusually high stiffness and resilience that results from planar-weaving of ribbons into corner topologies. Through experiments and numerical simulations we show that woven structures have a stiffness that can be comparable to a continuous non-woven counterpart made with the same amount of material. The woven baskets have a high stiffness because axial compressive loads are carried with all ribbons engaged similar to a continuous sheet. However, under large loads with global buckling, crushing, and wrinkling deformations, the woven baskets are much more resilient than their continuous counterparts. While the continuous sheets experience localized stress concentrations with plastic deformations, woven composites remain elastic and fully recover to their initial configurations. This high resilience is possible because the discontinuities between ribbons allow for segmented elastic buckling which deconcentrates stresses. We generalize the planar-woven basket corners to a family of corner geometries and assemble these to create functional robotic systems and stiffness-tailored metamaterials. The proposed concepts in basket weaving can be applied to create packaging, consumer products, furniture, automobile components, metamaterials, and other structural systems, where high stiffness and resilience to damage are desired.

*Speaker