Unlocking the Potential of Architected Materials: Insights from Nature and Beyond

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Abstract:

Our ability to improve multiple mechanical properties in engineering materials has been constrained by inherent trade-offs. In contrast, natural materials, despite their modest constituents, exhibit extraordinary mechanical properties, defying conventional limitations. For example, biological composites achieve remarkable toughness while preserving stiffness and strength through intricate hierarchical architectures. Exploring nature's strategies and unraveling the structure-function relationships within these materials has spawned fresh concepts in materials engineering. This convergence of ideas, coupled with advancements in material synthesis and additive manufacturing, has given rise to the field of architected materials. These materials have mesoscale architectures with customizable geometric features that unlock unique emergent properties previously unattainable with conventional counterparts. In turn, these materials are made of unit cells with very small structural members that are specifically designed to deform, bend, twist, buckle, or break in a certain way. Their collective behavior, somehow, gives rise to the new emergent properties. These materials consist of unit cells featuring small structural components meticulously designed to undergo controlled deformations, bending, twisting, buckling, or breaking in precise ways. It is the synergistic behavior of these unit cells that ultimately manifests the intriguing emergent properties we can then observe at the macro scale. During this presentation, I will delve into some interesting mechanics problems and challenges encountered while studying some exceptional biological and architected materials. I will also illustrate how the insights gained from these materials can be effectively applied to diverse engineering applications. These materials span the spectrum, ranging from high-strength and toughness to those exhibiting temporal morphing, shape-shifting, and actuation capabilities among others.

Bio:

Dr. Pablo Zavattieri, the Jerry M. and Lynda T. Engelhardt Professor in Civil Engineering at Purdue University, specializes in materials engineering and solid mechanics with focus on material design. He employs a diverse array of tools, including computational simulations, analytical techniques, and experimental methods, often utilizing additive manufacturing, to investigate the behavior and performance of architected and bioinspired materials. Dr. Zavattieri's current research program explores naturally-occurring architectures and their translation into engineering materials, including applications in the field of Concrete 3D Printing. He earned his BS/MS degrees in Nuclear Engineering from the Balseiro Institute (Argentina) and completed his PhD in Aeronautics and Astronautics at Purdue University in 2000. Before joining Purdue as a faculty member, he was a senior/staff researcher at the General Motors Research and Development Center from 2001 to 2009, where he led several initiatives in computational solid mechanics, smart and biomimetic materials.

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