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Material architecture and bio-inspiration as a strategy to enable new mechanical behavior

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ABSTRACT:

Our ability to improve more than one mechanical property in most engineering materials has been somewhat limited in the past by the inherent inverse relation between these desired properties often found in man-made materials. On the other side, Nature has evolved efficient strategies to synthesize materials that often exhibit exceptional mechanical properties that significantly break those trade-offs. In fact, most biological composite materials achieve higher toughness without sacrificing stiffness and strength in comparison with typical engineering material. Interrogating how Nature employs these strategies and decoding the structure-function relationship of these materials has opened up a new set of concepts in materials engineering. Considering the current progress in material synthesis and manufacturing, these new concepts have converged to the field of architectured materials. In this talk, I will describe some interesting mechanics problems that we encountered as we studied some extraordinary species, and how we can translate these lessons learned to architectured materials. This includes a review of an interesting crack twisting mechanisms found in the helicoidal architecture of the dactyl club of the Mantis Shrimp and some new competing mechanisms that we recently found in the exoskeleton of the diabolical ironclad beetle, a terrestrial beetle that is well known for its high compressive strength, far beyond any other beetle identified to date. These naturally-occurring high-performance structures have been shown to be very efficient at promoting delocalization of damage and, therefore, at avoiding catastrophic failure.

BIOGRAPHY:

Dr. Pablo Zavattieri is the Jerry M. and Lynda T. Engelhardt Professor in Civil Engineering at Purdue University. Zavattieri received his BS/MS degrees in Nuclear Engineering from the Balseiro Institute (Argentina) and PhD in Aeronautics and Astronautics Engineering from Purdue University. He worked at the General Motors Research and Development Center as a staff researcher for 9 years, where he led research activities in the general areas of computational solid mechanics, smart and biomimetic materials. His current research lies at the interface between solid mechanics and materials engineering. He has focused on the fundamental aspects of how Nature uses elegant and efficient ways to make remarkable materials and their translation to engineering materials. He has contributed to the area of biomimetic materials by investigating the structure-function relationship of naturally-occurring high-performance materials at multiple length-scales, combining state-of-the-art computational techniques and experiments to characterize the properties.