Cement-based 3D printed bioinspired architectured materials

Professor Pablo D. Zavattier

Lyles School of Civil Engineering, Purdue University,West Lafayette, Indiana 47907, USA

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There is a strong demand for new paradigms of design and development of high performance materials and structures where the main component is a brittle material. This is indeed the case for cementitious-based materials. On the other hand, there is a growing interest in Additive Manufacturing (AM) for cement-based materials. However, the intrinsic brittle behavior of these materials and the processing-induced interfaces represent major challenges. In our work, we make the case that additive manufacturing offers the opportunity to harness the role of interfaces, and we do that by exploring bio-inspired architectures as a way of controlling and diversifying the mechanical response of brittle cement paste elements. By natural selection, *Nature* has evolved efficient strategies to synthesize materials that often exhibit exceptional mechanical properties that significantly break the trade-offs often achieved by man-made materials. In fact, most highly biomineralized materials have high content of brittle minerals, contain a large population of defect and weak interfaces and yet they exhibit superior performance. In particular, I will discuss how Nature employs weak interfaces and clever architectures to achieve higher toughness without sacrificing stiffness and strength in comparison with typical engineering material. We then employ direct ink writing (DIW) to print elements in a layer-by-layer deposition process to evaluate the role of material behaviour, interfaces and bioinspired architectures on the mechanical response. Optical microscopy and X-ray micro computed tomography (micro-CT) were used to characterize microstructural features, such as heterogeneity of the pore network in interfacial regions (IRs) in the elements. Our results indicate that these new bioinspired architectured materials exhibit improved fracture resistance, delocalization of damage, enhanced energy dissipation and flaw-tolerant characteristics.

Bio: Dr. Pablo Zavattieri is a Professor of Civil Engineering and University Faculty Scholar at Purdue University. Zavattieri received his BS/MS degrees in Nuclear Engineering from the Balseiro Institute, in Argentina and PhD in Aeronautics and Astronautics Engineering. From 2001 to 2009, he worked at the General Motors Research and Development Center as a staff researcher, 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. His engineering and scientific curiosity has focused on the fundamental aspects of how Nature uses elegant and efficient ways to make remarkable and more sustainable 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. His current research program includes the study of remarkable naturally-occurring architectures and the translation to engineering materials, such as 3D printing of cementitious-based materials. Prof. Zavattieri is the recipient of the NSF CAREER award, the Roy E. & Myrna G. Wansik Research Award, he is a National Academy of Engineering Frontiers of Engineering Alumnus and a National Academy of Science Kavli Frontier of Science Fellow. He was also appointed a Purdue University Faculty Scholar for the period 2015-2020.