

# A new perspective on ancient materials inspires future innovation

November 21 2017, by Carolyn Schmitt

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Assistant Professor Admir Masic uses an x-ray fluorescence spectrometer to analyze ancient materials in Italy. Masic is at the forefront of an “antiqua-inspired” approach to new materials, which considers how ancient successes can be leveraged for the creation of new, sustainable materials. Credit: Lillie Paquette

Contemporary building materials are guaranteed for only about 100 years, yet structures built in Ancient Rome have survived for millennia. Questions about what accounts for this discrepancy in durability and resilience, and what engineers could learn from ancient technologies, are central to the research interests of Admir Masic, the Esther and Harold E. Edgerton Career Development Assistant Professor of Civil and Environmental Engineering at MIT.

"Ancient [materials](#) that have resisted degradation over time, and despite environmental conditions, can inform us about properties that contribute to performance and longevity," Masic says. "This 'antiqua-inspired' method offers a new way of approaching the creation of more sustainable, durable materials for the future."

To encourage peer researchers to consider how understanding [ancient materials](#) and processes can be leveraged for the development of innovative systems and devices, Masic, along with Loic Bertrand, the director of the IPANEMA European Research platform on ancient materials, a joint laboratory between the National Center for Scientific Research, Ministry of Culture, Versailles Saint-Quentin-en-Yvelines University, and University of Paris-Saclay; Claire Gervais, professor of materials chemistry at Bern University of the Arts; and Luc Robbiola, a research engineer at Toulouse University, composed a conceptual review of the many opportunities afforded by ancient materials. The paper, entitled "Paleo-inspired systems: Durability, Sustainability and Remarkable Properties," was recently published in *Angewandte Chemie International Edition*.

The "paleo- or antiqua-inspired" train of thought put forth by the researchers is modeled after the bio-inspired research approach, in which researchers look at the potential to learn from structures, composition, and outstanding properties of some biological materials to mimic and engineer new materials. As bio-inspired researchers use

natural occurrences, the paleo-inspired methodology explores ancient systems and processes, adding another dimension for looking towards the future of materials.



MIT students Clio Macrakis, Sierra Rosenzweig, Zoe Lallas, and Ahmad Mujtaba Jebran explore Pompeii as part of the program in Materials in Art, Archaeology and Architecture, a program Masic began to inspire and teach current students about the potential of ancient materials to inform the future. Credit: Max Kessler

In the paper, a variety of ancient technologies were presented, including Roman concrete, and pigments such as Mayan and Egyptian blues. In the case of the concrete recipe and methods used in Ancient Rome, the

concoction could be reverse-engineered to develop and optimize novel construction materials based on ancient practices and techniques.

Ancient Romans didn't use 3-D printing technologies or highly sophisticated nanomaterials in their construction. In fact, they came up with solutions that include volcanic ash or recycled materials, like brick fragments, to strengthen the concrete. Interestingly, these approaches have considerably less embodied energy than the commonly used Portland cement, and exhibit durability beyond the lifespan of modern infrastructure.

"This work opens exciting new avenues for the development of novel materials. There is a great deal that we can learn from antiquity, and in particular, traditional Roman concrete offers many potential advantages for construction in the future," says Class of 1942 Professor of Civil and Environmental Engineering and professor of architecture John Ochsendorf, an active proponent of antiqua-inspired structural designs. "We are really just beginning to understand the underlying chemistry of construction materials from antiquity."





Romans built structures with volcanic ash or recycled materials, like brick fragments, to strengthen the concrete, as seen in this wall in Privernum. This method is more sustainable and has less embodied carbon than modern cement mixtures. Credit: Lillie Paquette

The Masic lab, which was established in 2015, uses advanced characterization tools to design complex multi-scale materials, Masic explains. The Masic lab's position within the Department of Civil and Environmental Engineering (CEE) allows a unique opportunity for cutting-edge interdisciplinary ways of thinking about solutions for the future. This offers a new dimension for the lab to contribute to this new class of "antiqua-inspired" materials. For example, multi-scale computational modeling, combined with Masic's characterization tools, constitutes a powerful toolbox that will progress the design of innovative

solutions to cement and infrastructure long-term resilience.

The "antiqua-inspired" method is not limited to research, however. As part of the CEE undergraduate curriculum, students interested in materials and infrastructure are encouraged to take part in the program in Materials in Art, Archaeology and Architecture (ONE-MA<sup>3</sup>). In this three-week fieldwork program, students witness firsthand the durable structures and discuss ancient technologies with experts. The program is a prerequisite for 1.057 (Heritage Science and Technology), a class that combines lectures and labs, applying concepts and observations from ONE-MA<sup>3</sup> to antiqua-inspired research.

"ONE-MA<sup>3</sup> is a unique opportunity for undergraduate students to learn about the 'antiqua-inspired' concept in the field, and hopefully get inspired to contribute to the corresponding research," says Masic, the founder of the program. "Using ancient societies, architecture and building materials as time-proven examples of innovation in construction and material science, and building upon ONE-MA<sup>3</sup>, 1.057 introduces students to ancient materials and technologies and gives them the opportunity to explore material sustainability and durability from multiple perspectives."

**More information:** Loïc Bertrand et al. Paleo-inspired systems: Durability, Sustainability and Remarkable Properties, *Angewandte Chemie International Edition* (2017). [DOI: 10.1002/anie.201709303](https://doi.org/10.1002/anie.201709303)

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Provided by Massachusetts Institute of Technology

Citation: A new perspective on ancient materials inspires future innovation (2017, November 21)  
retrieved 3 May 2024 from  
<https://techxplore.com/news/2017-11-perspective-ancient-materials-future.html>

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