

Jan Zeman

“Wang tiles for exploring and manufacturing modular architected (meta)materials”

Initially conceived in 1961 as a visual aid for proving theorems in mathematical logic, Wang tilings have subsequently found applications in computer graphics, statistical physics, or biological computation. In this talk, we demonstrate the potential of Wang tilings in the design, robotic fabrication, and self-assembly of architected (meta)materials. The talk is divided into four parts. The first part presents a tiling concept in its simplest form. It uses a single parent tile, possibly rotated by 90 degrees, allowing the assembly of structures with a locally controlled Poisson ratio. In the second part, we show that the elementary scenario naturally extends to the framework of vertex-based Wang tilings and demonstrate its use in the design of a soft, porous metamaterial with a non-periodic structure. We emphasize the inherent modularity of this concept and show its potential for scalable robotic manufacturing. The third part of the talk is devoted to exploring the potential of the Wang tiling formalism in centimeter-scale passive self-assembly of target patterns. To this end, we present a design principle for magneto-mechanical tiles that self-assemble in a checkerboard pattern under external mechanical excitation while exhibiting robust error-correcting features during the self-assembly process. Finally, the inherent limitations of this approach are discussed, along with a simulation-based strategy for increasing the size of the self-assembled patterns. If time permits, in the fourth part, related developments in microstructure modeling, simulation, and topology optimization on non-periodic heterogeneous materials with Wang tilings will be promoted to highlight their broad applicability in multiscale materials modeling.



Dr. Jan Zeman is a Full Professor in the Theory of Materials and Structures at the Department of Mechanics, Faculty of Civil Engineering, Czech Technical University (CTU) in Prague. Currently a core member of CTU's Open Mechanics Group, Jan Zeman received his Ing. (MSc. equivalent) degree in 2000 and his Ph.D. in 2003 from CTU in Civil Engineering with a specialization in Structural Mechanics. He was awarded the 2000 Hlavka Talent Foundation prize (top CTU student) and the Ivo Babuška Award for the best Ph.D. thesis in Applied and Computational Mathematics and Mechanics in 2003. Jan's research interests lie at the interface between applied mechanics and mathematics, with a focus on modeling and simulation of deterministic and stochastic micro-structured materials, variational techniques for modeling inelastic materials, and mathematical analysis of engineering models and algorithms in general. His early work was supported by a Marie-Curie Intra-European Fellowship (2005), and, in addition to leading 6 projects funded by the Czech Science Foundation (CSF) from 2004 to 2024, he is currently the principal investigator of a highly selective five-year EXPRO project, a CSF initiative established in 2019, aiming at the computer-aided design of modular architected (meta-) materials, mechanisms, and structures. In addition to research, he is committed to mentoring talented future researchers and has (co-) supervised 8 Ph.D. candidates