The City College of New York

Grove School of Engineering
Department of Civil Engineering
Bruce Podwal Seminar Series
Tuesday, April 8, 2025 – 12:30 pm

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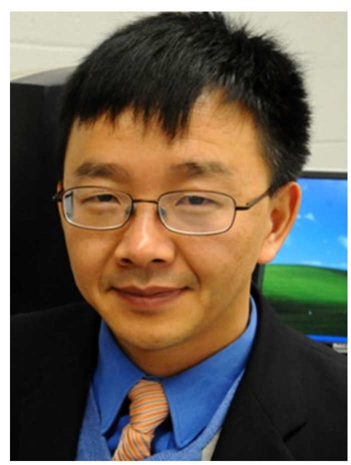
Singum-based homogenization of lattice materials and physical networks

Abstract:

Lattice materials in form of a network of bonds with connecting nodes are common in 3D printing metamaterials. When it is subjected to a mechanical load, the force passes through the network by the node-node forces, the effective material behavior depends on both the stiffness of each bond and the lattice structure. The recently developed singum model transfers the singular force network to a fully connected continuum particle system by Voronoi partitioning of the lattice. The singum stress and strain are defined as the average stress and displacement gradient, which are expressed in terms of the force and displacement. Given a variation of the singum strain, the tangential stiffness is obtained from the relationship of the singum stress-strain variations. When a pre-stress exists in the lattice, the stiffness tensor significantly changes due to the effect of the configurational stress. The anisotropy and asymmetry of the stiffness tensor for some unique lattice structures are demonstrated. Therefore, nonlinear elastic behavior of the lattice material can be solved by the boundary value problem with the effective stiffness of the singum continuum. The singum model has been applied to effective thermoelastic behavior of granular, cellular, and crystal lattices. The case study of a thin wall tube filled with a granular lattice demonstrates the novel material design and discovery for zero thermal expansion coefficient, tailorable stiffness and buckling resistance for space application. The singum model has been extended to flow problems of 2D physical networks, such as electric, pipeline, and transportation networks. The singum potential, flow, and potential gradient are defined and its application to routing and scheduling services is demonstrated.

Biographical Notes:



Dr. Huiming Yin received his Bachelor degree from the Hohai University, China, in 1995, Master degree from the Peking University, China, in 1998, and PhD degree from The Iowa University in 2004. Before joining Columbia University in 2008, Dr. Yin was employed by Caltrans as a Civil Engineer in the Transportation Laboratory at Sacramento, California, for two years and by University of Illinois at Urbana-Champaign as a Post-Doctoral Research Associate in the Department of Civil and Environmental Engineering for two years. Dr. Yin's research focuses on the multiphysical and mechanical characterization and modeling of civil engineering materials and their applications in energy efficient infrastructure systems. He received the NSF CAREER Award in 2010. He founded the Sustainable Engineering and Materials Laboratory and serves the Columbia Site Director of NSF IUCRC Center for Energy Harvesting Materials and Systems (CEHMS).

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