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ADVANCES IN COMPUTATIONAL MECHANICS FOR WAVE PROPAGATION, MULTISCALE AND MULTIPHYSICS SIMULATIONS

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ABSTRACT

This Mini Symposium will present recent advances in computational mechanics for wave propagation, multiscale and multiphysics simulations. The session will showcase state-of-the-art computational methods, novel material technologies, and advanced experimental characterization to develop resilience-enhanced engineering solutions.

A distinctive feature of this symposium is its breadth, spanning wave physics, structural and material modeling, and multiscale, multiphysics simulation, all built upon strong collaboration. A primary focus will be on wave-control technologies, including metamaterials and metasurfaces designed through inverse design, nonlocal scattering theory, and multiphysics optimization. These innovations have achieved unprecedented capabilities in manipulating elastic, acoustic, and electromagnetic wave propagation, enabling new strategies for seismic, blast, and vibration mitigation as well as tailored functional applications in optical and acoustic domains.

The symposium will also feature cutting edge computational frameworks for predicting material and structural behavior under extreme conditions. Highlights include nonlocal continuum formulations such as discretized peridynamics coupled with finite element methods for simulating fracture initiation, crack propagation, and progressive collapse in brittle, ductile, and heterogeneous solids. Other contributions address advanced soil-structure interaction models, absorbing boundary conditions for layered and anisotropic media, and probabilistic full waveform inversion techniques for subsurface characterization.

At the material level, research on ultra-high strength and fiber reinforced cementitious composites uses high resolution micro computed tomography to link pore scale structures with macroscopic mechanical and thermal properties under blast, seismic, and thermal loads. These developments are complemented by multiscale fracture modeling that integrates cohesive zone, virtual element, and phase field methods, ensuring predictive simulations are grounded in experimental data.

At the structural system scale, the session will cover wave and structure interaction modeling, structural fire performance assessment, and nondestructive monitoring for life cycle safety management. Time domain elastic wave formulations with enhanced absorbing boundaries improve the accuracy of large scale and unbounded domain simulations, while fire performance evaluations of composite systems inform resilience oriented design.

By uniting wave-control innovations, high fidelity simulations, advanced material development, and experimental verification, this symposium will present a comprehensive vision for next generation civil engineering systems. Applications will include nuclear containment structures, long-span bridges, high rise buildings, and functional material systems, demonstrating the transformative potential of computational mechanics in addressing real world engineering challenges and supporting sustainable infrastructure.

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