Research Group Profile

From Nanostructure to Infrastructure

Nano Infrastructure Research Group at the University of Mississippi

Goals: To understand the mechanics of nanomaterials in the multi-scale context and to use the nanomaterials for the improvement of the nation’s infrastructure.

Rationale: During the last two decades, tremendous progress has been made in nanoscience. New classes of nanomaterials, such as carbon nanotubes, nanofibers, nanowires, and quantum dots are being assembled atom by atom, with various high tech applications in mind—electronics, biomedicine, energy, environment, etc. However, these materials are still very expensive, and can only be produced in relatively small quantities. In order to protect the nation’s critical infrastructure, such as buildings, bridges, tunnels, transportation systems, pipelines, power transmission and communication systems against natural (hurricane, flood, earthquake) and man-made (blast, impact, fire) threats, we need huge quantities of low cost nanomaterials. In fact, not all nanomaterials are man-made and expensive: there are abundant, naturally occurring and low cost materials that are at or near nano size, such as nanoclay, volcanic ash, cellulose nanowhiskers, and many carbon- or silica-based minerals. Recent study of mechanics at micro and nano levels has confirmed that the material behavior can be controlled by constituents at the nano size. Mixing a small quantity of clay, graphene, POSS, and carbon nanotube with polymers can significantly alter material strength and other mechanical properties. The strength of cement is strongly influenced by the packing of the calcium-silica-hydrate gel at the micro level. Hence, with the understanding of material laws at the micro and nano levels, it may be possible to design infrastructure materials such as green concrete and building blast protection materials such as nanoparticle-enhanced polymer sprayed on walls. The goals of this research group are to study multi-scale material behavior and to apply the research outcomes to protect the nation's critical infrastructure.

Sample Research Topics:

• Molecular dynamics simulation of concrete, geomaterials, and nanocomposites.
• Continuum theory bridging molecular, micro, macromechanics.
• Multi-scale modeling of cementitious materials.
• Design of impact, blast, and shock resistant sandwich composites.
• Nanoparticle reinforced polymer spray for concrete masonry unit blast protection.
• Earthquake- and blast-resistant structural components and systems.
• Fire-resistant protective materials.
• Particle, discrete element, and mesh-less numerical modeling.
• Dynamic, impact, shock tube, and blast experiments on composites.

Recent Projects:

• Nanoparticle-reinforced composites for critical infrastructure protection, Southeast Region Research Initiative, Department of Homeland Security. Link
• Blast- and impact-resistant composite structures for Navy ships, Office of Naval Research.
• Structural, material, and geotechnical solutions for levee and floodwall construction and retrofitting, Southeast Region Research Initiative, Department of Homeland Security. [Link]
• Dynamic response and simulations of nanoparticle-enhanced composites, Office of Naval Research.
• Stochastic modeling of progressive damage in polymer concrete composites, Air Force Lab.

People:
Ahmed Al-Ostaz: Experimental and computational mechanics, nanocomposites, cementitious materials, random composites, multi-scale modeling, impact and blast loadings. Email: alostaz@olemiss.edu
Alexander Cheng: Nanomechanics, poromechanics, mesh-less collocation method, porous medium flow. Email: acheng@olemiss.edu, homepage: http://home.olemiss.edu/~acheng/
Elizabeth Ervin: Contact, impact, and blast dynamics, structural health evaluation, experimental techniques, Multi-Function Dynamics Laboratory. Email: eke@olemiss.edu, homepage: http://home.olemiss.edu/~eke/
Raju Mantena: Grid-stiffened and nanoreinforced composites, impact/ shock/ blast characterization, vibrations and experimental modal analysis. Email: meprm@olemiss.edu
Chris Mullen: Nonlinear finite element modeling, earthquake engineering, structural engineering, progressive failure. Email: cvchris@olemiss.edu
Chung Song: Geo-nanomechanics, multi-scale mechanics, coupled theory of mixtures, finite strain plasticity of geomaterials. Email: cssong@olemiss.edu
Ge Wang: Computational mechanics, computational fracture mechanics, computational fluid dynamics, sediment transport, turbulent flow, atmospheric flow. Email: gewang@olemiss.edu, homepage: http://home.olemiss.edu/~gewang/

Selected Publications:
• Wang, G., Al-Ostaz, A., Cheng, A.H.-D., and Mantena, P.R. (2008), Particle Modeling of a Polymeric material (nylon-6, 6) due to the Impact of a Rigid indenter, Computational Materials Science (available online).

More publications: [Link]

Links:
Department of Civil Engineering, University of Mississippi: http://www.olemiss.edu/depts/civil_eng/
Nanocomposite infrastructure protection project site: http://www.olemiss.edu/sciencenet/SERRI/
Composite Structure and Nano Engineering Group: http://www.olemiss.edu/research/csnerg/composite/
Mississippi Center for Community Earthquake Preparedness: http://www.olemiss.edu/orgs/ccep/
Multi-Function Dynamics Laboratory: http://home.olemiss.edu/~eke/MFDL.htm

Contact: Alexander Cheng, Email: acheng@olemiss.edu