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.

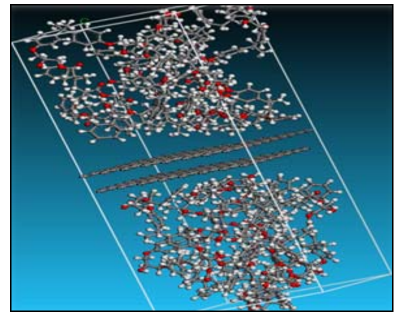
Rationale: During the last two decades, tremendous progress has been made in nanoscience. New classes of nanomaterials, such as carbon nanotubes, nanofibers, nanowires, and quantum dots are being assembled atom by atom, with various high tech applications in mind—electronics, biomedicine, energy, environment, 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 and fly 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.

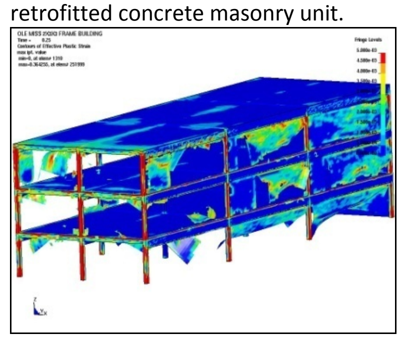
Recent Projects:

- 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.

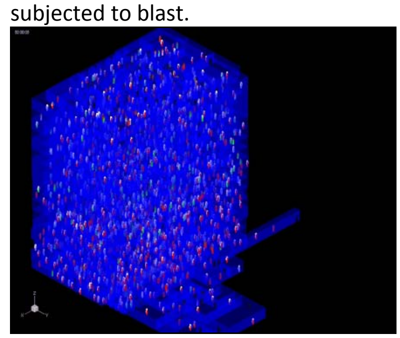


xGnP (exfoliated graphene nano particle) embedded in vinyl ester

Blast experiment of POSS-polyurea retrofitted concrete masonry unit.



LSDYNA simulation showing a building without nano-particle-reinforcement subjected to blast.



Agent-based evacuation simulation for a nano-particle-reinforcement retrofitted building.

- 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

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Chung Song: Geo-nanomechanics, multi-scale mechanics, coupled theory of mixtures, finite strain plasticity of geomaterials. Email: csong@olemiss.edu

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Selected Publications:

- Al-Ostaz A., Pal G., Mantena R. P., and Cheng A.H.-D. (2008), "Molecular dynamics simulation of SWCNT-polymer nanocomposite and its constituents," Journal of Materials Science, Vol. 43 (1), pp. 164-173.
- Mantena R. P., Al-Ostaz A., and Cheng A.H.-D. (2008), "Dynamic response and simulations of nanoparticle-enhanced composites," Composite Science and Technology (available online).
- Alzebdeh K.I., Al-Ostaz, A., and Alkhateb, H. (2008), "Parametric evaluation of progressive damage in polymer concretes: Size effect and statistics," Vol. 32 (4), pp. 336-351.
- Alkhateb, H., Al-Ostaz, A., and Alzebdeh, K.I. (2008), "Developing a stochastic model to predict the strength and crack path of random composites," Journal of Composites: Part B (available online).
- Voyiadjis, G.Z. and Song, C.R. (2002), "Multi-Scale Non Local Approach for Geomaterials," Mechanics Research Communications, Vol.29 (2-3), pp. 121-129.
- Song, C.R., Wu, W., Al-Ostaz, A., and Voyiadjis, G.Z. (2008), "Effects of Force Field in Molecular Mechanics Simulation of Geo-Materials," Mechanics Research Communications, submitted.
- Song, C.R. and Voyiadjis, G.Z. (2007), "Analytical Observation of Micro-Mechanical Interactions in Plasticity of Saturated Soils," International Journal of Plasticity, in press.
- Ervin, E.K. "Vibro-Impact of Two Orthogonal Beams," *ASCE Journal of Engineering Mechanics,* submitted.
- Wang, G., Al-Ostaz, A., Cheng, A.H.-D., and Mantena, P.R. (2008), "Hybrid lattice particle modeling: theoretical considerations for a 2-D elastic spring network for dynamic fracture simulations," Computational Materials Science (available online).
- 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).
- Wang, G., Radziszewski, P. and Ouellet, J. (2008), "Particle modeling simulation of thermal effects on ore breakage," Computational Materials Science, 43, 892-901.

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

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