Research Group Profile

Nano Infrastructure Research Group
At University of Mississippi

From Nanostructure to Infrastructure

Problem

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.

Approach

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, Polyhedral Oligomeric Silsesquioxane (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 blast protection materials such as nanoparticle-enhanced polymer sprayed on walls.

Core Competencies

- **Mult-hazard evaluation: Blast/ shock/ impact, fire, earthquake, hurricane and aginging infrastructure.**
- **Nano materials for infrastructure protection**
- **Bio-inspired materials.**
- **Sustainable, environmental friendly (green), and energy efficient structures.**
- **Molecular dynamics simulation of concrete, geomaterials, and nanocomposites.**
- **Continuum theory bridging molecular, micro. macromechanics.**

This research group focuses on utilizing recent advances in nano science and nano engineering for infrastructure applications using multiscale experimental and numerical methods.

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Recent Finding

This group established a benchmark analysis of infrastructure facilities subject to blast and other extreme loadings, which includes disaster simulation, mapping protection barrier, evaluation of evacuation procedure, and proposing structure improvement through retrofitting and the use of high-performance materials, including nano-structured materials. More details may be found at:

http://www.olemiss.edu/sciencenet/SERRI/

Impact

Build a safer, more secure, and more resilient America by enhancing protection of the Nation's critical infrastructure and key resources to prevent, deter, neutralize, or mitigate the effects of deliberate efforts by terrorists to destroy, incapacitate, or exploit them; and to strengthen national preparedness, timely response, and rapid recovery in the event of an attack, natural disaster, or other emergency. The current research focus is one of the few that apply the latest technology in nano particles and nano-structured materials to the protection of the nation's critical infrastructure The current project is unique in that it is a multi-level research that progressively increasing scales from material level, to structural components, to structural systems, and to decision support systems.

Selected Publications

1. 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.
2. Mantena R. P., Al-Ostaz A., and Cheng A.H.-D. (2008), "Dynamic response and simulations of nanoparticle-enhanced composites," Composite Science and Technology, Vol. 69 (6),pp.772-779.
3. 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.
4. Wang, G., Al-Ostaz, A., Cheng, A. H-D., and Mantena, P. R. (2009), "A macroscopic-level hybrid lattice particle modeling of mode-I crack propagation in inelastic materials with varying ductility," International Journal of Solids and Structures, Vol. 46, pp. 4054-4063.

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