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" Granular micromechanics: a paradigm for micromorphic continuum mechanics "

by

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Abstract

Granular materials take a variety of forms, spanning the spectrum from highly consolidated dense solids formed of particulate precursors to confined packing of non-cohesive particles. In all their forms, these materials are characterized by complex structures and compositions. More importantly, they share the common trait that their behavior at the macro-scale, that contains large numbers of grains (>106), is profoundly affected by the grain-scale interactions. For many important problems in engineering and science, continuum description of their mechanical behavior is desired. Discrete atomic or coarse-grained models often pose insurmountable challenges. Granular micromechanics method is a practical approach for continuum modeling these materials. In this approach, the material representative volume element (RVE) is modeled as a collection of grains which are interacting with each other through different inter-granular mechanisms. The resultant models offer the versatility of investigating the influence of both the macro-scale parameters and the grain-scale parameters on the overall stress-strain response by incorporating the effect of nearest neighbor grain interactions through the inter-granular force-displacement relationship and orientation vector. We have been developing the granular micromechanics approaches since 1980s. In their earlier formats, the models based upon granular micromechanics were successful in describing the small strain behavior. In recent years, these models have undergone further refinement and have been successfully applied to model a number of phenomena exhibited by granular geomaterials. In particular, the models have been shown to successfully describe the damage and softening in cementitious materials [1]. The approach also leads to a 2nd gradient continuum theory involving strain gradient and its conjugated double stresses useful for modeling shear bands [2]. The method has also been extended to include rate effects [3], incorporate thermomechanical consistency [3,4] and develop efficient numerical scheme [5] that can be implemented into finite element formulation. The model predictions have shown both quantitative and qualitative consistency with the observed behavior for asphalts and cementitious materials [3-5, 9]. Recently, the method has been extended to include non-classical terms which lead to micromorphic models [6,10]. The derived model has been applied to study the wave dispersion relationships and topology optimization [8]. Method for identifying elastic constants for the derived model has been demonstrated for regular and irregular grain assemblies by performing discrete simulations [7]. In the proposed presentation, we will describe some of the recent developments in granular micromechanics.

Biography

Anil Misra received his bachelor's degree in civil engineering from the Indian Institute of Technology, Kanpur, India, and his M.S. and Ph.D. degrees from the University of Massachusetts at Amherst. He is currently a Professor in the Civil, Environmental and Architectural Engineering Department of the University of Kansas, Lawrence. He also serves as Associate Director of the University of Kansas Bioengineering Research Center (KU-BERC). Dr. Misra has a broad research interest that spans topics covering both basic and applied aspects of mechanics of geomaterials, interfaces and biomaterials, including analytical, computational and experimental granular micromechanics, particle and atomistic methods, multi-scale modeling, constitutive behavior, micro-macro correlations, and multi-modal material characterization using high resolution techniques. He has co-edited three books; guest edited three journal special issues; and authored more than 200 papers in journals, edited books and conference proceedings. He has made more than 100 presentations of his research results at national and international fora. His research has been funded by a variety of sources, including the United States National Science Foundation, National Institute of Health, and private industry. He is active in various professional societies and serves as reviewer and editorial board member of a number of journals. (webpage: http://people.ku.edu/~amisra/)

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