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DEM modeling of oil sands materials structures

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Oil sands are composite materials whose two dominant physical characteristics are the quartzose mineralogy and the large quantities of interstitial bitumen. The void spaces are also filled with a thin continuous net of water around the quartz grains with the remaining space occupied by dissolved gasses. An examination of thin sections and electron scanning micrographs reveals a typical particulate system, whose mechanical behavior can be modeled based on particle interactions (contacts) at the microscale. The oil sands formation exhibits mainly a dense, interpenetrative, uncemented structure with a large number of contacts per grain. Additionally, oil sand undergoes high dilation under low normal stresses. In this paper, the microstructural and micromechanical behavior of oil sands materials is studied and an appropriate and comprehensive contact model is identified to describe its nonlinear, anisotropic and time-dependent behavior. A 2-D discrete element method (DEM) is developed to model the oil sands structures using DEM software package, Particle Flow Code (PFC2D). The time-dependent behavior of the bitumen (consisting of bonded fine particles) is represented by a Burger's model. The quartz grains are modeled with irregular (subrounded and subangular) shape clumps (a rigid collection of disc bonded together). The thin-film of water surrounding the quartz grains is represented as a liquid bridge to determine the capillary force at the interface. The micromechanical model of the oil sand was developed with three different constitutive laws (force-displacement contact models) to represent the contact interactions of the constituents at the microscale. The paper provides theoretical foundations for understanding machine-ground interactions during excavation and for material behavior predictions. Understanding the microscopic behavior of oil sands materials would enhance long-term equipment design improvements and provide production engineers with higher equipment longevity and reliability for mine production and maintenance planning purpose.

Biography

Samuel Frimpong has obtained his PhD in 1992 from University of Alberta and MS in 1988 from University of Zambia. He has obtained his Post-graduate Diploma in 1986 and BS in 1985 from KN University of Science and Tech. of Ghana. He guided over 30 PhD and MS graduates, published 1 book, 3 book chapters, over 200 refereed journal and conference papers and given over 200 presentations. He is a Member of the APLU Board on Natural Resources, Vice Chair of the Minerals and Energy Resources Division of NASULGC, and a Member of the College of Reviewers for Canada Foundation for Innovation and Canada Research Chairs Program and ASCE-UNESCO Scientific Committee on Emerging Energy Technologies (ASCE-UNESCO SCEET). He served 5 years as a Member of CDC-NIOSH Research Advisory Board, 4 years as Co-chair of ASCE-UNESCO SCEET and 2 years on Japan's Global Warming Research Consortium. He is currently the Editor-In-Chief of the *Journal of Powder Metallurgy and Mining* and Editorial Board Member for the *International Journal of Mining, Reclamation and Environment*. He is a Registered Professional Engineer and a member of the Canadian Institute of Mining, Metallurgy and Petroleum, American Society for Mining, Metallurgy and Exploration, American Society of Civil Engineers, and the Society for Modeling and Simulation International.

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