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CIVIL & ENVIRONMENTAL ENGINEERING SEMINAR SERIES

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The Impact of Shale Softening on Enhanced Hydrocarbon Recovery and Sustainable Geo-Energy Storage

Shales are tight rocks with ultra-low porosity and contain hydrocarbon (oil and gas). Both the United States (USA) and Israel have abundant shale formations containing oil and gas. The USA is currently the largest oil and gas producer in the world with the majority of its shale hydrocarbon production from the Permian basin, Texas, whereas the largest kerogen shale deposits in Israel occur in the Shfela area. To improve the recovery of oil and gas from shale, shale formations are hydraulically fractured by injecting water-based fluids under high pressure. To address sustainability and global warming, it is now proposed to store greenhouse gases (CO_2) and offshore wind energy (H_2) in shale formations once oil and gas are depleted. Shale is composed of clays and silts, and they are bound by carbonates to form ultra-tight matrices that contain interconnected nano- to micro- to macro-voids with total porosity of 1-6%. These voids store oil and gas. Shale formations were isolated for millions of years and now the introduction of fracturing fluids, as well as CO_2 and H_2 gases, causes the ultra-tight shale matrix to soften, and causing some of the voids to seal preventing the extraction of oil and gas as well as possible storage of CO_2 and H_2 gases. The interaction of fracturing fluids and shale formations, leading to softened shale, is now attributed to the interlayer expansion of clays and dissolution of carbonates. However, no such explanation exists for the interaction of CO_2 and H_2 gases. The shale softening and its impact on nano- to micro-scale pores have major implications for energy recovery and environmental sustainability. In this project we are investigating the effect of shale softening on enhanced oil and gas recovery, as well as on the performance of geo-energy storage capacity in order to achieve energy sustainability and mitigate global warming. The softening effect is due to hydro-thermo-chemo-mechanical interaction between shales and various fluids under high pressures and temperatures. We are now investigating the pore-scale softening of shales with the injection of different fluids and gases under high pressure and temperatures to quantify the shale softening, and further propose a comprehensive model to predict shale softening. Two shale samples were obtained from Permian basin, Texas and Shfela area in Israel, to perform this exploratory laboratory and theoretical research, and obtain preliminary data. We aim to quantify the shale softening and assess its implications on enhanced recovery of hydrocarbon and storage of CO_2 and H_2 gases in shales.

Thursday, December 8th, 2022 l 10:00 AM EDT l 17:00 Israel Time
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Dr. Jay N. Meegoda, P.E., is a professor of civil and environmental engineering at NJIT and has been working as educator, consultant and researcher in engineering for over 42 years. He utilizes scientific concepts and engineering technologies in his research to provide solutions to real world problems. Dr. Meegoda has worked with state and local governments, and foreign governments to provide technical input for broad range of problems. At NJIT, Dr. Meegoda as PI has successfully concluded several multidisciplinary research projects worth over $8M from agencies such as NSF, USEPA, US Army, US Airforce, FHWA, NJDOT and NJDEP that provided broader impact to the society. Some of those technologies are now extensively used while others are to be commercialized. He has over 260 publications. He had many research collaborations with many nations spanning all five continents. He received the research implementation award from the New Jersey Department of Transportation in 2011 for his Culvert Information Management Research, the best theoretical paper award from the Environmental and Water Resources Institute of ASCE in May 2012 for his collaborative research with China and the best practice paper award from the Environmental and Water Resources Institute of ASCE in May 2001 for the paper describing the results of one USEPA SITE demonstration project. He was instrumental in setting up the NJIT chapter of Engineers without Borders and is currently the faculty advisor for the chapter.