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High Resolution Dual Modality (Neutron and X-ray) Imaging of Granular Materials and Direct Numerical Simulations

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This presentation will summarize the ongoing research of Mr. Felix Kim (PhD student of Dr. Penumadu) on the high resolution neutron (∼13.7 μm/voxel) and X-ray (∼11.2 μm/voxel) tomography imaging of partially water saturated compacted sand specimens. Neutron imaging work was performed at Helmholtz Zentrum Berlin (HZB) in collaborations with Drs. Kardjilov and Manke. Two different particle grain morphologies (round and angular) were used. Partially saturated granular assembly is a three phase material consisting of solid phase (Silica: SiO2), gas phase (air), and liquid phase (water). Due to different attenuation characteristics of neutrons and X-rays to these three phases of interest, neutron and X-ray images provided unique but complementary information. While the water phase contrast is well identified with cold neutron images without using a contrast agent, the detailed structure of silica sand phase is much clearly shown in X-ray images due to low attenuation of air/water phases to X-rays. This presentation will provide a detailed description of neutron and X-ray tomography techniques employed. An automatic approach to register the dual modality image in the same coordinate is also demonstrated. Direct numerical simulation technique based on the realistic pore geometry obtained from X-ray tomography of dry sand specimen is also demonstrated. Pore morphology method was used to predict capillary water distribution and capillary pressure - saturation curve as an example. Neutron imaging shows promise for interesting and multi-disciplinary research and the planned VENUS imaging beam line at the Spallation Neutron Source at Oak Ridge National Laboratory and the existing thermal imaging beam line at NIST will also be introduced.

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