Feeling the force between sand grains

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LLNL researchers have measured how force moves through 3D granular materials such as sand and soil. Photo by Sean O’Flaherty.

For the first time, Lawrence Livermore National Laboratory (LLNL) researchers have measured how forces move through 3D granular materials, determining how this important class of materials might pack and behave in processes throughout nature and industry.

Granular materials such as sand, rice and soil exist everywhere around us. However, scientists and engineers do not yet fully understand how external forces move through these materials. The ability to quantify that force transmission is missing, yet critical in efforts to predict material behavior.

Using X-ray diffraction, computed tomography and new mathematical analysis, the team measured how forces move through a slowly compressed, opaque 3D granular material. The new technique confirmed that forces move spatially through granular materials in patterns that agree with theory and simulations, and tend to behave more uniformly as load is increased.

"Understanding how forces move through granular materials is important for building models and predicting the behavior of geologic materials such as sands and soils (e.g., when they fracture and flow during hydraulic fracturing and when they are penetrated to defeat buried enemy targets)," said Ryan Hurley, an LLNL scientist and lead author of the study appearing in the Aug. 19 edition of the journal, *Physical Review Letters*.

Hurley also said that the research is relevant to the packing properties of everything from pharmaceutical pills, food grains in silos and additive manufacturing powders.

In their experiments, the researchers found that the various mathematical tools scientists use to understand these patterns are incomplete and often conflicting.

"The research sets the stage for further characterizing forces in larger 3D granular systems under more varied loading conditions," Hurley said. "This characterization will enable more predictive modeling of processes throughout nature and industry."

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