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DEPARTMENT OF MECHANICAL ENGINEERING

DISSERTATION DEFENSE

Particle Friction, Breakage, and Damage: Deformation Mechanisms of Brittle Granular Materials

by

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Understanding the mechanics of granular materials is essential in geophysics and for a broad range of industries and for defense-related applications. However, predicting the mechanical behavior of granular materials is still challenging, and even their most basic micromechanics remain poorly understood. This thesis sheds light on the micromechanics of granular materials by examining their friction, breakage, and damage. The friction between grains constituting a granular material was examined using a new micromechanical testing apparatus to study smooth and rough soda-lime glass particles in carefully controlled dry, humid, and lubricated environments during normal compression and shearing. The breakage of granular particles was studied across strain rates and pressure regimes using confined uniaxial strain experiments performed in an oedometer, a drop tower, and a split-Hopkinson bar. These experiments provided some of the first data quantifying particle breakage at stresses up to several gigapascals. This study also used *in-situ* acoustic emissions measurements to study deformation mechanisms active throughout the compaction process during low strain-rate experiments. The mechanical response of Ottawa sand was further investigated by studying the impact of projectiles into dry and wet sand targets. We specifically examined depth of penetration, breakage, and *in-situ* displacement fields reconstructed using a novel method. Damage of inter-particle bonds was examined by studying sintered soda-lime glass at the microscale using interparticle bond tensile testing and at the macroscale using unconfined uniaxial compression testing of cylindrical core-drilled samples.

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