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Exploring the relationship between critical state and particle shape for granular materials

J. Yang[1]* and X.D. Luo[1]

Abstract

The relationship between critical state and particle shape corresponds to the most fundamental aspect of the mechanics of granular materials. This paper presents an investigation into this relationship through macro-scale and micro-scale laboratory experiments in conjunction with interpretation and analysis in the framework of critical state soil mechanics. Spherical glass beads and crushed angular glass beads of different percentages were mixed with a uniform quartz sand (Fujian sand) to create a sequence of mixtures with varying particle shape. On the micro scale, particle shape was accurately measured using a laser scanning technique, and was characterized by aspect ratio, sphericity and convexity; a new shape index, taken as the average of the three shape measures and referred to as overall regularity, was proposed to provide a collective characterization of particle shape. On the macro scale, both undrained and drained triaxial tests were carried out to provide evidence that varying particle shape can alter the overall response as well as the critical states in both stress space and volumetric compression space. The mixtures of Fujian sand and spherical glass beads were found to be markedly more susceptible to liquefaction than the mixtures of Fujian sand and crushed angular glass beads. The change in liquefaction susceptibility was shown to be consistent with the change in the position of the critical state locus (CSL) in the compression space, manifested by a decrease in the intercept and gradient of the CSL due to the presence of spherical glass beads. Quantitative relationships have been established between each of the critical state parameters and each of the shape parameters, thereby providing a way to construct macro-scale constitutive models with intrinsic micro-scale properties built in.

Keywords: Constitutive relations; Critical state theory; Granular material; Particle shape; Shear behavior

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