ABSTRACT

Liquefaction is a devastating instability associated with saturated, loose, and cohesionless soils. It poses a significant risk to distributed infrastructure systems that are vital for the security, economy, safety, health, and welfare of societies. In order to make our cities resilient to the effects of liquefaction, it is important to be able to identify areas that are most susceptible. Some of the prevalent methodologies employed to identify susceptible areas include conventional slope stability analysis and the use of so-called liquefaction charts. However, these methodologies have some limitations, which motivate our research objectives. In this dissertation, we investigate the mechanics of origin of liquefaction in a laboratory test using grain-scale simulations, which helps (i) understand why certain soils liquefy under certain conditions, and (ii) identify a necessary precursor for onset of flow liquefaction. Furthermore, we investigate the mechanics of liquefaction charts using a continuum plasticity model; this can help in modeling the surface hazards of liquefaction following an earthquake. Finally, we also investigate the microscopic definition of soil shear wave velocity, a soil property that is used as an index to quantify liquefaction resistance of soil. We show that anisotropy in fabric, or grain arrangement can be correlated with anisotropy in shear wave velocity. This has the potential to quantify the effects of sample disturbance when a soil specimen is extracted from the field. In conclusion, by developing a more fundamental understanding of soil liquefaction, this dissertation takes necessary steps for a more physical assessment of liquefaction susceptibility at the field-scale.