The Fundamental Mechanism of Shear of Granular Material along an Interface

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Research Funded By: Air Force Office of Scientific Research & NSF
Date: Summer 1997

ABSTRACT

Since the pioneering work by Karl Terzaghi early this century, soil mechanics has evolved to an engineering discipline in which advanced mechanical principles and techniques are employed for solving soil related problems. Soil is a special type of particulate material, which has traditionally been treated as a continuum media. The success of the continuum mechanics approach underlines the facts that many engineering problems involving soils are of a large scale, for which the continuum approach provides adequate solutions. Some fundamental phenomena like dilation during shear and arching remain unique features of discontinuous materials. Better understanding of the mechanical behavior of particulate material calls therefore to employ a microscopic approach which takes into account the individual particle displacement and inter-particle interactions as well as the interactions between particles and other structure elements (e.g., foundations, tunnels and geosynthetic materials).

This research aims to investigate experimentally the mechanical behavior of idealized two-dimensional particulate material when sheared along an interface with a solid surface (of different roughness). The kinematics and interparticle interactions of all particles in the model are monitored, measured and analyzed. Correlation are attempted to be made between the global interfacial behavior to the discrete variations of the individual particles.

The primary tool implemented in this research is an image acquisition and analysis system, which consists of two high resolution digital CCD cameras, computers and an image analysis software. The two CCD cameras are synchronized with one acquires images of particle motion and the other acquires photoelastic images.

It is found that the normalized roughness relating the solid surface asperities to the particle size determines the shear failure mode along the interface. A smooth solid surface does not mobilize the internal shear strength of the particulate material, and shear failure occurs along the interface. A rough solid surface causes the shear failure to take place within the particulate material and hence the internal shear strength of the particulate material is fully mobilized. Shear mode is identified as an important factor affecting the interfacial shear strength as well as the mechanism of shear failure through the imposed boundary conditions. Arching has been recognized to have a significant contribution to the interfacial shear strength under certain boundary conditions. Though it has been realized by previous researches that boundary conditions affect the outcome of testing results, this research successfully revealed the mechanism and manner (at a microscopic level) in which the boundary conditions affect particle displacement and interparticle interactions.

Idealized particles implemented in this research enables to control the testing conditions and hence warrants the systematic investigation of multiple factors relevant to the interfacial behavior.