Chapter 8

DEM Studies on the Liquefaction Behavior of Particles With Different Aspect Ratios

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ABSTRACT

Discrete element method (DEM) provides insight into the fundamental physical principles leading to a better understanding of the complex behavior of granular materials under different loading conditions. In the reported studies adopting DEM, real particle shape is ignored, and the particles are modeled as spheres. Spherical shapes are preferred as they provide the simplest case with least computational effort in calculations and efficient algorithms. Hence, in this study, a comprehensive and comparative study on the mechanical behavior of assemblies consisting of particles with different aspect ratios is reported. The results indicate that the assemblies with lower aspect ratio lose its strength completely at less number of cycles when subjected to lower confining pressures. At higher confining stresses, the particles are not quick enough to rearrange themselves resulting in the reduction of average coordination number. This causes a drop of shear strength leading to lower resistance to liquefaction for non-spherical assemblies at high confining stresses.

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INTRODUCTION

Earthquake loadings simulate undrained conditions on sandy soils leading to a sudden surge in pore water pressure. This type of dynamic loading leads to degradation of stiffness which ultimately leads to a reduction in shear strength of the soils. An analysis of the effects produced by liquefaction indicates that it varies from the destruction of shallow buildings to the life lines of cities. Examples on the hazard impacts on the normal life due to liquefaction can be clearly observed from the earthquakes which occurred in a sequence during 2010-2011 in Christchurch New Zealand. Recent earthquakes which produced significant liquefaction related damage include Chile (2010), Christchurch New Zealand (2011) and Tohoku Earthquake, Japan (2011). The casualties and the hazards caused by liquefaction results in huge economic loss.

A large amount of research has been carried out to understand the behaviour of granular materials subjected to static and dynamic loading by analytical, physical and laboratory experiments. But it is well proven that these methods cannot shed light into the fundamental aspects of granular behaviour. In granular media, whether it is field observation or laboratory experiment or numerical modeling, it is understood that the macroscopic behaviour is dependent on the particle level mechanics. So understanding the internal structure and its evolution during loading is significant. Cundall & Strack (1979) proposed the Discrete element method (DEM) which tracks the movement of individual particles and further updates the contact forces and contact displacement of individual grains through a discrete element cycle. For numerical simulations, DEM is followed in this study.

BACKGROUND

The dynamic properties of the soil mass which include shear modulus and damping ratio are key parameters which control the behaviour of a soil deposit. The degradation of the strength parameters plays a very important role in the behaviour during cyclic loading. Laboratory cyclic triaxial tests and low strain tests have the limitations of providing the dynamic properties at the measured strain level. Also, in the case of laboratory tests, the difficulties associated with the preparation of samples having the same initial properties, the effect due to the rubber membrane and the non-uniform distribution of stresses and strain are very predominant. However, the numerical methods adopted for the modelling of the dynamic response of the soil subjected to earthquake loading effectively eliminates most of the problems faced by the laboratory tests. The initial arrangement of the particles in a sample or its fabric has significant effect on the liquefaction and post-liquefaction behaviour of
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