The Effect of Particle Grading on the Mechanical Behavior of a Granular Assemblage - Discrete Element Approach

DONG JING JING

Department of Civil and Environmental Engineering

University of Macau

Abstract

The macroscopic response of a granular assemblage is clearly governed by the particle characteristics at the particulate level, such as the particle size distribution (particle grading). In this investigation, the discrete element method (DEM) was employed to investigate the effects of particle grading on the macroscopic response of such a graded assemblage. The study is divided into two parts. In the first part, a series of numerical triaxial tests was carried out by a three-dimensional discrete element code PFC^{3D} on a representative volume of a particle assemblage. A cube enclosed by six rigid boundaries was used as a representative volume subjected to the triaxial shearing condition. Spherical shaped particles with different particle size distributions characterized by a different coefficient of uniformity c_u were generated randomly inside the representative volume to form the graded assemblage. Numerical triaxial drained and undrained (simulated by constant volume shearing) compression tests with different initial densities and confining pressures were conducted by controlling interplay among the boundary walls. The effects of particle grading on the assemblage's stress-strain-strength response, hardening behavior and critical state are studied and discussed. In general, the stress-strain-strength response, hardening behavior and critical state are significantly affected by c_u. It is found that assemblage with wider particle size distribution (corresponding with larger c_u value) has lower stiffness. The critical state line of such assemblage locates at a lower position in an

e-logp' plane.

In the second part of the study, the DEM results are compared with the simulation by an elastoplastic continuum cohesionless material model that proposed by Li and Dafalias (2000). Incorporating a state-dependent dilatancy function, the model is able to simulate both contractive and dilative response of a granular material under a wide range of density and pressure with a single set of model constants. It is found that the model constants exhibit highly dependency on c_u of an assemblage. The elastic parameter G_0 is decreasing with the increasing c_u value. The critical state parameters e_Γ and λ_c are sensitive with particle grading and both of them decrease with the increasing c_u value. The dilatancy parameter d_0 increases with c_u which means that with more small particles, the soil is more difficult to dilate. Hardening parameter n increases with c_u which indicates the hardening tendency of a well-graded material.