8th International Congress on Civil Engineering,
May 11-13, 2009, Shiraz University, Shiraz, Iran

Discrete element simulations of assemblies of two-dimensional irregularly-shaped particles and effects of particles shape on mechanical behavior

S. Abedi[1], A. A. Mirghasemi[2]

1-Graduate student of geotechnical engineering, School of civil engineering, University of Tehran, Tehran, Iran

2-Associate professor, School of civil engineering, University of Tehran, Tehran, Iran

saba_abedi_a@yahoo.com
aghasemi@ut.ac.ir

Abstract

Several researchers have investigated the effects of grain's shape on the physical behavior of granular materials. The results of researches show that grain's shape has considerable effects on the engineering properties of their assembly in granular soils. Therefore adequate grain shape modeling is quite important. A discrete element method has been developed to simulate assemblies of two-dimensional irregularly-shaped particles to study the mechanical behavior of granular materials. Each particle's shape is assumed to be represented by combining circular elements so that adequate particle shape modeling is obtained. The program DISC (Bathurst, 1985) which is a modified version of BALL (Cundall, 1978) was adopted and modified to simulate assembly of particles which are represented according to above assumption. Then, series of biaxial tests are conducted on assemblies of particles with different shapes. The focus of this study is on effects of grain's shape on mechanical behavior of simulated granular material. Results for assemblies of angular grains and rounded grains are presented in terms of macro mechanical behavior.
Keywords: Irregular grain shape, Discrete element simulation, Numerical modeling

1. INTRODUCTION

In the discrete element method (DEM) scheme proposed by Cundall & Strack(1978), the grains were modeled as discs in 2-D simulations [1]. Simulations with discs have simple calculations; Contact detection doesn't need complicated algorithms. Also in simulations circular grains move easily besides of each other, because of easy rotation. But this model has problems in conformity with reality; Resistance to rotation is much less for circular grains compared to that of the actual grains. The internal friction angle of shearing resistance for circular grains modeled using DEM is much less than that of the actual grains with irregular shapes. Also, Circular grains have an inherent tendency to roll. On the other hand, the direction of the contact normal forces is always toward the center. So, these forces never contribute to the moments acting on the grains and rotation is only affected of contact tangential forces. Because of these problems, different shapes for grains were proposed to be used in DEM simulations in order to improve simulations.

Many research studies have conducted on the granular soil behavior with elliptical grain's shape so far [2,3,4]. Modeling with elliptical grains has these advantages: elliptical grains have fewer tendencies to rotate and simulated mechanical behavior is similar to that of real soils. Ellipse-shaped grain also has a unique outward normal; Generalization of this method to 3-D is simple. Elliptical grains, however, don't accurately represent grain's shapes.

Many researchers have studied the soil behavior with polygon-shaped grains [5,6,7]. The results show that a more realistic representation of soil behavior can be achieved. However, this method has intensive calculations because edge-to-edge, vertex-to-edge, vertex-to-vertex contacts should be investigated; It leads to significant increase in time for running the program. Vertices of each polygon don't have unique normal vector, so the estimation of forces is difficult.