Evaluation of the influence of particle size on characteristics of particle shape using an automated particle image analysis

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1. Introduction

In many fields dealing with geology, the relation between particle morphology in the soils and various phenomena is widely studied. Particle morphology indicates particle size, particle shape and various other characteristics. In particular, size and shape are complementary relationship. As a previous research, we reported the results of particle shape evaluation of volcanic ash whose particle size was evaluated using a sieve, and clarified that particle size evaluation using a sieve is affected by the particle shape. [1]. Notable aspect of size and shape distribution matters are its having inversed relationship qualitatively. Typically, in soil, the finer particle are relatively more circular shape than the coarse particle. This is because, for example, finer particles are presumed to be provided by abrasion fracture when falling from a rock surface due to ground distortion and/or rising. Therefore, the simultaneously integrated investigation between size and shape is important.

The existing technology to investigate size and shape matter are the microscopic technics, sieving, sedimentation and laser diffraction analysis. Challenges of existing technologies on above are that it is each independent technic to investigate between size and shape. Especially, microscopic analysis is the near impossibility of measuring a statistically significant number of several ten thousand number of particles as recommended in ISO 13322-1,2 and quantitatively information. Recent advances in computer technology have allowed for a new automated particle image analysis (APIA) approach.

We reported and discuss about capability of APIA method was useful to resolve these issues on the model soil samples considerd fracture processes as one of realistic ground mechanics process.

2. Material and method

Sea sand, 300~600um(30~50mesh) (FUJIFILM Wako Pure Chemical Corporation) was used for this study. A part of the sample was milled with a ball mill (Mini Mill 2, FRITSCH).

As APIA system, Morphologi 4 (Malvern Instruments) was used for evaluation of particle size and shape. The observation mode was diascopic mode (Transmittance mode) and magnification was 125x in total magnification. The sample was dispersed with SDU (Sample Dispersion Unit) which attached Morphologi 4. Number of measured particles is over than 2,000 and parameter filter function on software was used based on shape and pixel number of particle image.

3. Result

Mean value of Circularity for original sea sand and 5 minutes milled sea sand is shown in Table 1. All particle circularity of original sea sand is smaller than all particle circularity of 5 minutes milled sea sand. For particles larger than 150um, circularity both original sea sand and 5 minutes milled sea sand are almost same. Particle of the same size as before milling, that is, particles of a large size, were simply particles that were not milled. Therefore, it is considered that these particles maintain their shape.

Focusing on the small particle size, it was confirmed that the trend was the same as the trend of all particle. In particular, the circularity of particles smaller than 20um was almost the same as the circularity of the whole particles. This is a simple result comes from the number ratio of particles smaller than 20um is highest (Percentage of particles by particle size is shown in Table 2).

These data will discuss in detail on that day.

4. Conclusions

It was confirmed that particle shape changes according to particle size with APIA method. The particle shape results from the shape of the particles in numerical majority. It is also revealed that it is necessary to use a number-based particle size distribution device to understand the number of particles by particle size.

[1] Aiko Hayauchi, Daisuke Sasakura. “An evaluation of sieving effect of volcanic ash fine particles by a statistical particles image analysis” JPGU2013 Abstract.

Keywords: Particle shape, Particle size, Maprticle morphology

Classification by particle size(um)	Circularity Mean		
	Original	5 minutes milled	⊿(original/5 minutes milled)
All	0.75	0.82	0.07
CED>=150um	0.74	0.75	0.01
150um>CED>=74um	0.71	0.76	0.05
74um>CED>=38um	0.73	0.78	0.05
38um>CED>=20um	0.75	0.80	0.05
20um>CED	0.76	0.83	0.07

Table 1: Mean value of circularity for original sea sand and 5 minutes milled sea sand

Classification by particle size(um)	Count based ratio(%)		Volume based ratio(%)	
	Original	5 minutes miilled	Original	5 minutes miilled
CED>=150um	22	0.059	99.9	12
150um>CED>=74um	4.3	1.1	0.11	39
74um>CED>=38um	6.4	6.0	0.023	31
38um>CED>=20um	11	18	0.0045	13
20um>CED	56	75	0.0027	6.0

Table 2: Percentage of particles by particle size

