Variation characteristics of the grain size distribution of gravel by rotary crushing and mixing method focused on single particle strength test

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1. Introduction

Currently, a large amount of high-quality soils is required of large projects in japan. But high-quality soil is insufficient. Due to the lack of soils and environment destruction. For that reason, unsuitable soils should be used to solve this problem. In this paper, the rotary crushing and mixing method (Twister method) was dealt for the following reasons. Twister method is applicable cohesive soil and soft rocks as well although the type of soil was difficult to handle for soil improvement and crushing and mixing are done in large quantities with conveyor belts. In order to make efficient use of the Twister method, this paper focused on the single particle strength test, and conducted a basic study on the variation of the grain size distribution of gravel materials by twister method.

2. Experimental equipment

2-1. Method of TM-500

TM-500 was used for the experiment in this study with 500mm of cylinder diameter and the method is shown in Figure 1. Materials can be put on the conveyor belt for crushing and mixing it into the cylinder uniformly. Inside the cylinder, there are 3 floors each floor consists of 4 flexible chains and the striking force of rotating chains pulverizes the soil into fines. By adjusting the number of rotations up to 1200 rpm (rpm: revolutions per minute), the particles can be crushed in various ways.

2-2. Method of Single particle strength test

Single particle strength test was carried out to obtain the strength of the particles. Single particle strength test requires three similarly sized particles placed roughly at the apexes of an equilateral triangle between two steel plates. However, a simpler point-load set-up has been adopted here as an index test for particle strength. It is believed that the testing of individual particles simplifies the procedure to investigate the single particle strength.

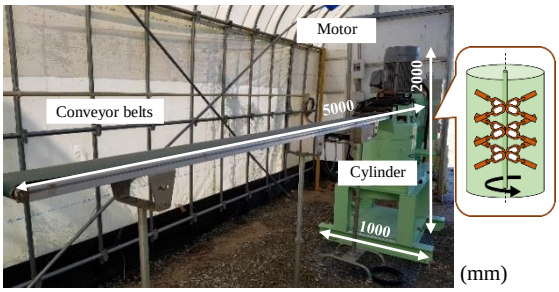

Fig 1. Outline of twister machine

Table1. Samples used in this study

Rpm \ Samples		Crush stone C-1	Crush stone C-2	RC40 RC-1	RC40 RC-2	RC40 RC-3
D_{50} (mm)	0	23.5	41.8	13.4	22.5	31.5
	400	22.1	41.0	12.3	21.5	30.5
	800	20.2	28.1	10.0	11.1	9.9
	1200	8.5	13.1	5.2	4.2	4.0
U_C	0	1.46	1.53	1.45	1.19	1.20
	400	1.81	1.64	1.95	2.07	1.71
	800	4.09	5.83	5.95	9.27	10.08
	1200	6.81	8.95	9.43	12.00	11.00
Source		Obtained by crushing rocks		Recycled concrete such as building		

3. Samples and methodology

Crush stone and RC40 samples were used for this experiment. The samples were classified into five categories according to the grain size, some fundamental index properties of each sample are given in Table1.

First, before the crushing test using TM-500, each sample were tested for grain size distribution curve. Each sample of 1kg were placed on the conveyor belt from 1m before the input for crushing. The number of rotations was set 400, 800 and 1200rpm.

Single particle strength test was carried out on 10 particles whose 50% diameter of particles, D_{50} was close to each sample, displacement and strength were measured in 3 seconds. Samples that cannot clearly crushed were tested for up to 90 minutes.

4. Results and discussion

Figure 2 is a typical graph of the single particle strength test results. P_{f1} is defined as the first partial particle crushing force and F_{max} are defined as the strength of the particles by Lee (1975). The single particle strength test graph showed the crushing patterns of samples. Crush stone was not crushed at once, and it was shattered little by little. In the case of RC40, cracks were formed at the end and the fracture was largely broken into two or three pieces. It is thought that it will be a factor in the change of particle size when it is crushing test using twister machine.

Box and whisker plot (box plot) was used to compare the strength of the samples. It is a convenient way of visually displaying the data distribution through their quartiles. Although box plots may seem primitive in comparison to a histogram or density plot, they have the advantage of taking up less space, which is useful when comparing

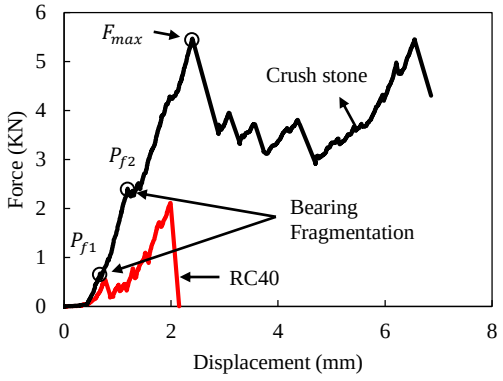

Fig 2. Typical Force of particles

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distributions between many groups or data-sets. RC-1 and RC-3 have similar average value of force. But RC-3 is tightly data grouped than RC-1. And there is outlier in RC-1 and RC-2. It means that the composition of the particles is not a close group. And Median of RC40 was proportional to the D_{50} (Fig. 3).

The first biggest fracture force, F_{max} depends on the size of the particles and their tensile strength. Data of the mean of $\sigma_C = F_{max}/A$ for each sample against the mean particle size are plotted in Fig 4. A was calculated as $A = (D_{50})^2$ because it is difficult to measure the joint surfaces of particles.

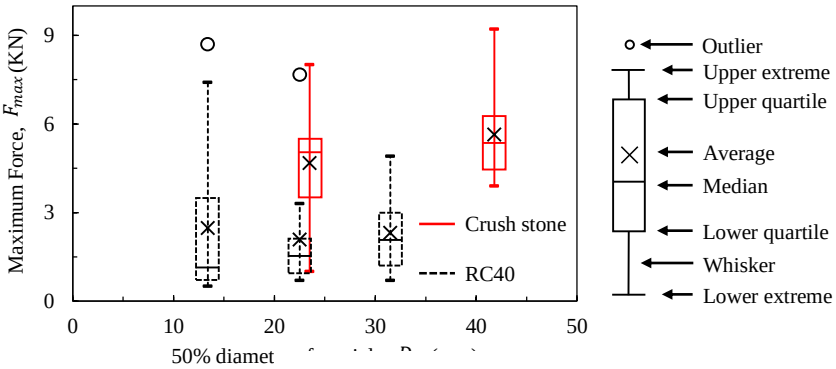

Fig 3. Relationship

The samples were compared with toyoura sand, angular glass (A.G.), lightweight aggregate (L.A.) and quiou sand on the north coast of France by Kato et al (2001.3). Both the crush stone and RC40 exhibit near linear decline in strength with increasing particle size in the full logarithmic plot. it was similar to the result of sand. the smaller the particles size have greater crushing stress. The slope can be calculated to estimate the crushing stress of different size particles (Fig 4.).

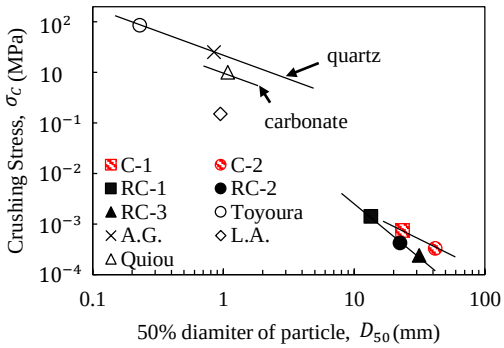

Fig 4. Relationship between σ_C and D_{50}

Figure 5 shows the typical crushing results of crush stone and RC40 between before and after crushing for 400, 800 and 1200 rpm. Samples were not significantly different between the pre-crushing curve and curve of 400 rpm. At 1200 rpm, the shape of the curves was almost straight.

The variation of coefficient of uniformity (U_C) of the samples according to the number of rotations was compared as shown in Table1. All the samples before crushing were poorly-graded samples that did not meet standard of Japanese Geotechnical Society (JGS) because U_C of samples were smaller than 4 (U_C <4). In the standard of JGS, if the U_C of gravel is greater than or equal to 4 (U_C ≥4) and C_g is 1-3 (1≤ C_g ≤3), it is well-graded. In Table 1, U_C was not satisfied with JGS at 400 rpm, and it was satisfied from 800 rpm.

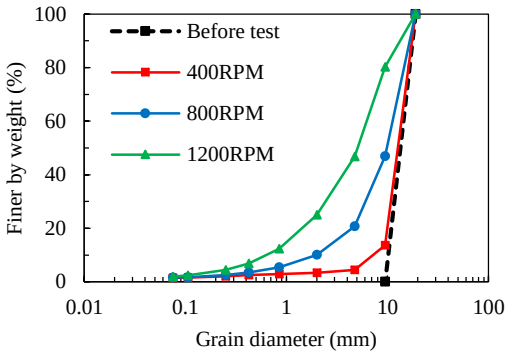

Fig 5. Typical record of samples

5. Conclusions

The characteristic of crushing by twister method is investigated using single particle strength test. The main conclusions are as follows

(1) The crushing pattern and strength of particles were found. It is thought to be an important factor in crushing tests using twister method.

(2) A variety of stresses in the particles have been confirmed through the degree of scattering.

(3) Crushing stress defined can be predicted according to particle size shown Fig 4. σ_C depend on not only D_{50}, but also the quality of mother materials consisted.

(4) The samples did not satisfy the JGS standard. Samples after crushing became well-graded gravel using twister method.

In the future, the factors that change according to the number of rotation and their crush mechanism will be studied. And the relationship between the characteristics of the particles obtained in this study and the twister method will be examined.

Reference

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