Experimental study on void ratio characteristics of sand-finesmixture

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Abstract: Void ratio characteristics of sand-fines mixtures have been investigated in this study. After result analysis of 54 specimens, conclusions are summarized, which shows that most fine-sand mixtures reach extreme value of e_{max} and e_{min} at the fines content of 30% to 50%. It is found that 3rd degree polynomial equations are appropriate to illustrate void ratio characteristics of sand-fines mixture. And the uniformity coefficient of sand plays an important role in determining the reduction of e_{max} and e_{min} with fines content.

Keywords: Fine-sand mixture; Maximum void ratio; Minimum void ratio; Uniformity coefficient

1 INTRODUCTION

Sand is commonly considered as a natural granular material, and always is described by the parameters of sand particles, grain-size distribution, void ratio, mineralogy, fines content and so on. The most meaningful measures of packing behavior, representing the states of densest and loosest random packing of sands, are the maximum void ratios e_{max} and minimum void ratios e_{min} (Panayiotopoulos, 1989). A lot of studies on these two parameters have been taken and mainly focused on clean sand (Selig and Ladd, 1973), such as, relation between the material properties and e_{max} or e_{min} of sands (Miura et al., 1997), the use of void ratio range for sand classification and so on (Shimobe and Moroto, 1995; Cubrinovski and Ishihara, 1999). Effects of fines on e_{max} or $e_{min}$of sands have been studied to examine the influence of fines on undrained behavior of sands (Thevanayagam, 1998). Moreover, other studies show that 3rd degree polynomial equations are reasonable to estimate the variation of minimum and maximum void ratios for fines-sands mixtures (Y.Yilma, 2009).

This study was taken to test and characterize the packing behavior of fine-sand mixtures by evaluating the parameters of e_{max}, e_{min}, which is one part of collaborative research carried out by geotechnical group of Kyushu University and Kyushu Electric Power Company, which is focused on the capillary ability of sandy soil mixed with different content fines. Some experiment results and findings are also present in this paper.

2 MATERSITIED TESTED

The fines, on the other hand, have various degrees of uniformity and commonly contain percentage of clay size particles, and are considered as noplastic material (Cubrinovski, M., Ishihara, K., 2002). In this study, two kinds of fines named fine1 and fine 2, are mixed with four sands with the name of sand A, sand B, sand C and Sand D, respectively.

The particle size distribution curves of six samples are shown in Fig.1, while grading and void ratio properties of them is given in Table 1. As testmaterial, fines 1 and fines 2 are bought from The Association of Powder Industry Process and Engineer, Japan, sand A is Japanese standard sand for geotechnical experiment, Toyoura sand, and B, C, D sands are collected and recomposed from Masa soil of Japan.

Table 1. Grading properties of sands and fines used

Soil type	e_{max}	e_{min}	D_{50}(μm)	C_u
A	1.436	0.837	227.81	1.97
B	1.596	0.700	196.61	4.74
C	1.119	0.827	1998.23	1.59
D	0.969	0.492	892.94	3.99
1	1.149	0.667	25.03	1.93
2	1.410	0.615	24.97	4.67

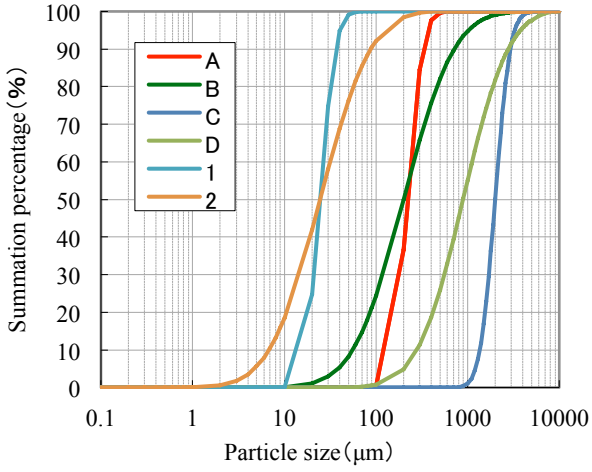

Fig.1.Particle size distribution curves of 6 samples

3 TESTING RESULT AND ANALYSIS

3.1 Testing result

Fines 1, 2 samples are respectively mixed with other four sand samples A, B, C, D, individually at 0%, 10%, 20%, 30%, 40%, 50%, 75% and 100% by dry mass. In this way, 54 different sand-fine mixtures specimensare formed. Maximum and minimum void ratios have been determined according to the proceduresstipulated by Japanese Geotechnical Society (JGS). Variations of e_{max} and e_{min}, for all the composite soils, are shown in Fig. 2 and Fig. 3 respectively.

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As shown in Fig.2 and Fig.3, it's indicating that, e_{max} and $e_{min}$of six sand-fines mixtures initially decreases with the fines content increase from 0% to 30%.Moreover, these two parameters rapidly increase while the fines content increase from 50% to 100%. e_{max} and e_{min} approximately reach their extreme values at the fines content of 30% to 50%. Similar results have been addressed in the studies byLade, P. V. et al (1998).But the curves of B+1 and B+2 have distinguishing characteristics comparing to the former six soils, as fines content increase.

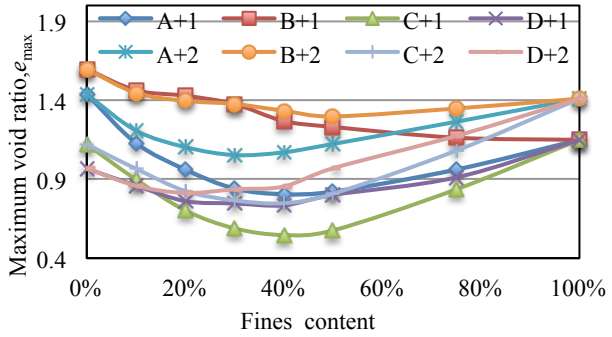

Fig.2. Variation of e_{max} with fines content

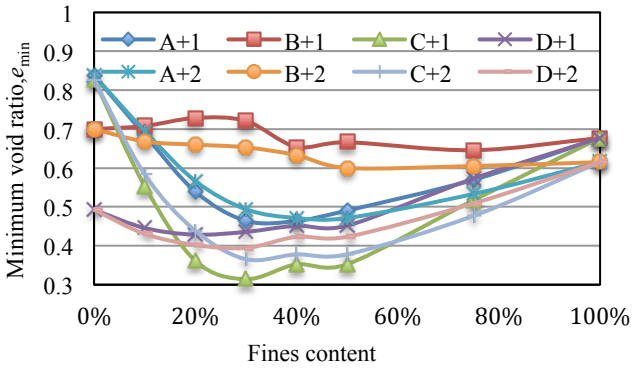

Fig.3. Variation of e_{min} with fines content

3.2 Analysis

It's found from Fig.2 and Fig.3 that 3rd degree polynomial equation is exactly describing the relation between fines content and void ratio parameters, and the fit indexes are more than 90% for all the curves. The relationship of e_{max} or e_{min} with fines content is affected by the grain size distribution, in particular, by that of sand. To quantify the results, the reduction in e_{max} and e_{min} between 0% and 30% fines content is plotted versus uniformity coefficient of sand in Fig.4, where the reduction is denoted by e_1 and e_2. Noted that e_1 and e_2 reduce as the liner relation to the uniformity coefficient of sand. And there is no clear reduction in e_{max} and e_{min} when uniformity coefficient reaches approximately 5, which is the reasonfor the distinguishing characteristics of B+1 and B+2 mixtures.

4 CONCLUSIONS

Based on the result and analysis of void ratio test of fine-sand mixtures, the following conclusions can be summarized:

(1) Most fine-sand mixtures reach minimal value of e_{max} and e_{min} at the fines content of 30% to 50%, and comparing to fine gradation, sand gradation is more sensitive for e_{max} and e_{min}.

(2) This study verifies that void ratios of mixtures may be determined reasonably well using appropriate 3rd degree polynomial equations as function of fines content.

(3) Reductions in e_{max} and e_{min} have the liner relation to the uniformity coefficient of sand, and the reduction isn't clear as uniformity coefficient reaches approximately 5.

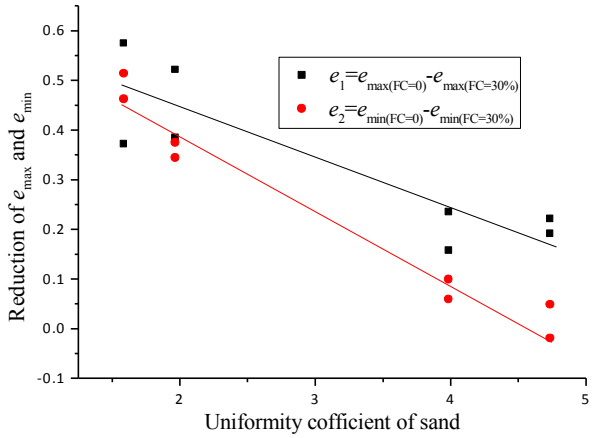

Fig.4. Variation in reduction of e_{max} and e_{min} versus uniformity coefficient of sand

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