Effect of Variation in Sample Sizes on Soil-Polymer Interface Strength

S. Imaizumi
Utsunomiya University, Japan

T. Nishigata
Kansai University, Osaka, Japan

K. Iimura
Miyaji-Tekkou Co. Ltd., Japan

ABSTRACT: A comparison of sand-polymer interface strength tested, at a normal stress less than 100 kPa, by varying the sample size in a fixed mode direct shear box test is shown. Four different shear box sizes were used. Two types of cohesionless sand and a smooth HDPE with a thickness of 1.0 mm were employed. It is found that the use of small shear boxes increases the frictional coefficients with decreasing normal stress and that the larger the length of shear box the lower the frictional coefficient at a given normal stress.

1 INTRODUCTION

The frictional strength between the soil and geomembrane is a essential design parameter to estimate a stability of side slopes and/or anchorage ability of geomembrane in waste landfill (Koerner, 1990). To determine the soil-geomembrane interface strength, the engineers have to carry the pull-out test or direct shear test. The many engineers and researchers have made almost use of the direct type shear test (Ingold, 1991). Among the types of direct shear apparatus, fixed shear box seems to be prevail because it is easily altered from the apparatus for soil by replacing the lower box to steel block base.

According to a review of testing procedure (Takasumi, Green and Holtz, 1991), a variety of sizes of shear box from conventional 60- by 60-mm to 460- by 460-mm have been employed. But few researchers have commented on the effects of apparatus (or sample) size on interface strength.

In this paper, the effects of sample size on sand-polymer interface strength which was tested at normal stresses lower than 100 kPa were investigated.

2 APPARATUS AND PROCEDURES

Three kind of apparatuses were used. The first was a conventional direct shear one, popular to a geotechnical engineers for actual soil tests, which had a circular shear box with a diameter of 30-mm or with that of 60-mm. The second had square shear box of 316- by 316- mm. When these two apparatus were used for soil-polymer interface strength, a steel block base replaced the lower box. The last had a rectangular upper box with length of 208-mm by width of 158-mm and lower steel block. This was as same type as Yegian's apparatus (Yegian, 1992) and used only for soil-polymer interface strength.

In the case of testing the frictional interface strength of soil-polymer, polymer liner was glued to base block and then wiped by acetone to remove perspiration and dust. The dry granular soil was tamped into upper shear box for it's relative density to be 80 % . A shearing force was applied for lower base (upper box as to the second apparatus) to move at a rate of 1mm/min.

3 MATERIALS

HDPE (High Density Polyethylene) with a thickness of 1.0 mm was used. A tensile strength at yield was about 22 MPa for dumbbell shape sample. A frictional angle for residual strength of HDPE-HDPE interface was 11 degrees when it was estimated by direct shear test after acetone-wiping the surface.

Table 1 Physical Properties of Sands

	Top Size (mm)	Coefficient of Uniformity; Uc	Specific Gravity
Toyoura	0.84	1.34	2.64
Inagi	0.84	2.24	2.70

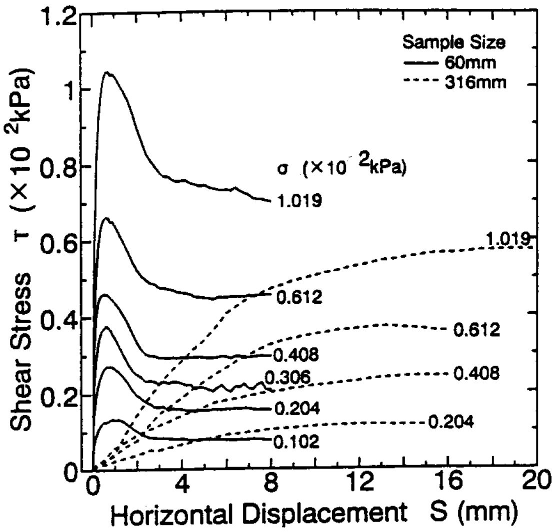

Fig. 1 Stress-displacement curves for actual Toyoura-sand

Two kind of soil, Toyoura-sand and Inagi-sand, were employed as granular soil. Their properties are listed in Table 1. The percents retained on No.200 sieve are less than 3 % for both soils. Therefor they are both uniformly graded sand. Their relative density of 80 % corresponded to dry unit weight of 15.4 KN/m3 for Toyoura-sand and of 16.5 KN/m3 for Inagi-sand.

Typical stress displacement curves for Toyoura-sand are shown in Fig. 1. The tests of 60-mm diameter sample provide a peak strength at a horizontal displacement of less than 1 mm, whereas in tests of 316- by 316-mm sample the shear stress increase gradually with displacement. This trend is similar as to Inagi-sand. The average frictional angles concerning peak strength of Toyoura-sand and Inagi-sand are 43.3- and 44.9-degrees when tested with small sample and 31- and 35-degrees when tested with large sample, respectively.

4 RESULTS AND DISCUSSION

Figs. 2-5 show the relation between horizontal displacement and interface shear stress for

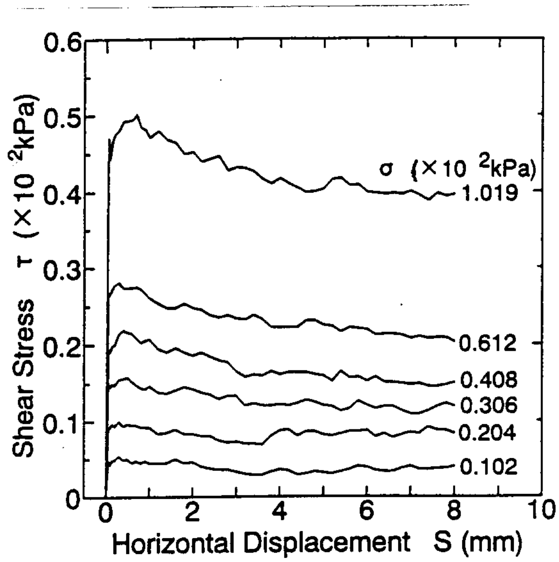

Fig. 2 Stress-displacement curves for HDPE-Toyoura sand (Sample size: 30-mm diameter)

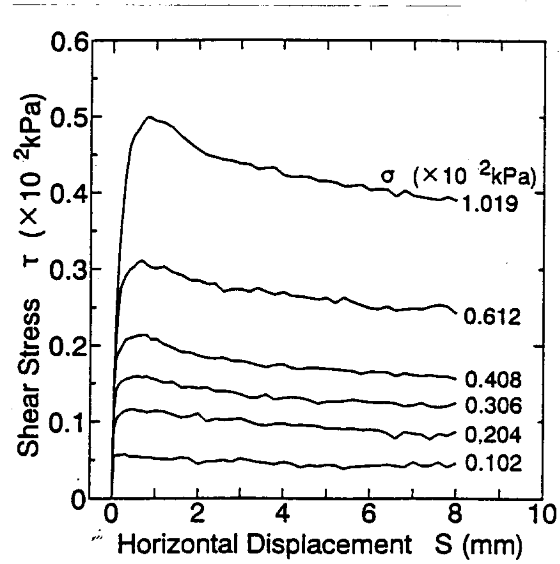

Fig. 3 Stress-displacement curves for HDPE-Toyoura sand (Sample size: 60-mm diameter)

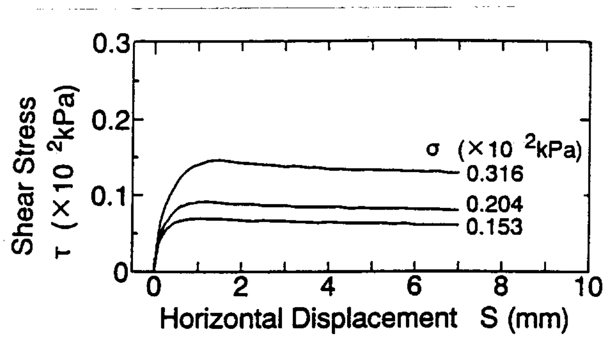

Fig. 4 Stress-displacement curves for HDPE-Toyoura sand (Sample size: 208- by 158-mm)

Toyoura-sand and HDPE. Though the curves have a peak of shear stress in all tests, they are considerably different depending on sample size. It seems that increasing of a sample size provides decrease of peak shear stress,

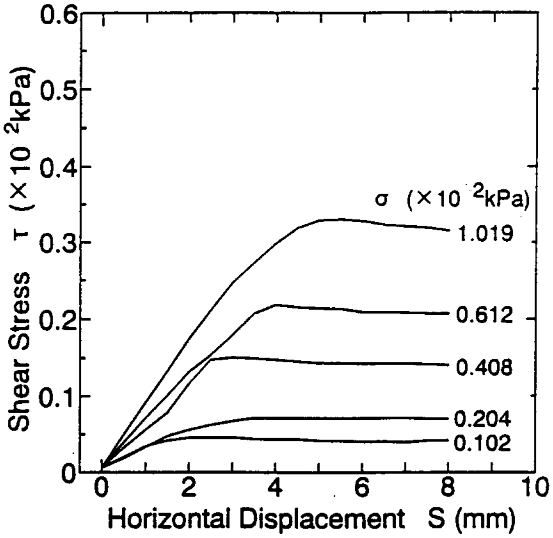

Fig. 5 Stress-displacement curves for HDPE-Toyoura sand (Sample size: 316- by 316-mm)

decrease of reduction from peak to residual stress and increase of horizontal displacement up to peak stress. The trends of Inagi-sand, of which figures are not presented because of limitation of space, are almost as same as Toyoura-sand.

The frictional coefficient was defined as a ratio of peak interface shear stress to corresponding normal stress. Figs. 6-7 indicate frictional coefficient versus sample size. The coefficients resulted from 60-mm sample is almost same as those from 30-mm sample, but are higher than those from lager sample size. Moreover, whereas using a large apparatus coefficient holds nearly constant over wide rang of normal stress, it seems to increase with decreasing of normal stress when using smaller sample. Two reasons was considered. One is addition of normal force induced by friction between sand and side wall of upper box, which make a larger effect on resultant at lower normal stress, because a ratio of a wall area to section one becomes smaller with increasing of sample size. Other is a effect of progressive failure along interface as mentioned below.

Figs. 8-9 show a horizontal displacement at peak strength versus sample size. As to every normal stress, lager sample size takes larger displacement. If a soil might slide as a rigid body, the peak shear stress might mobilize at a unique horizontal displacement under a given normal stress without reference to a difference of sample size. But experiments showed dissimilar. This suggests that a local displacement along interface is not uniform and larger displacement may develop from the edge

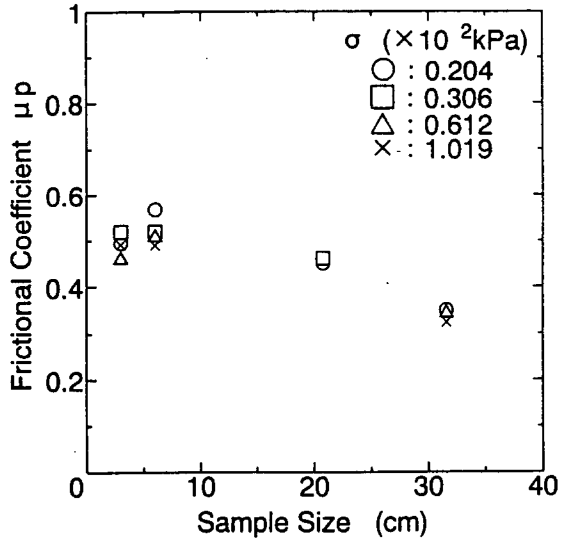

Fig. 6 Frictional coefficient versus sample size for HDPE-Toyoura sand

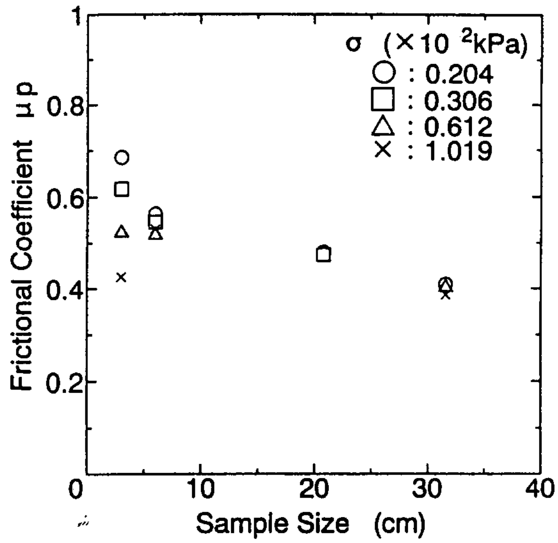

Fig. 7 Frictional coefficient versus sample size for HDPE-Inagi sand

to center of sand according to addition of shearing force, which also implies an ununiform distribution of shear stress. This is a behavior called progressive failure. Therefor, the reason why a frictional coefficients decrease with a sample size as shown in Figs. 6-7 is that a progressive failure may occur along a interface.

A frictional efficiency was defined as a ratio of frictional coefficient of sand-HDPE interface at given normal stress to that of actual sand. Figs. 10-11 indicate the efficiency versus normal stress, from which the efficiency is independent from normal stress. It is also found that a larger size apparatus provides high values of efficiency of 60-mm apparatus by about 1.2 times and those of 30-mm one by about 1.9 times.

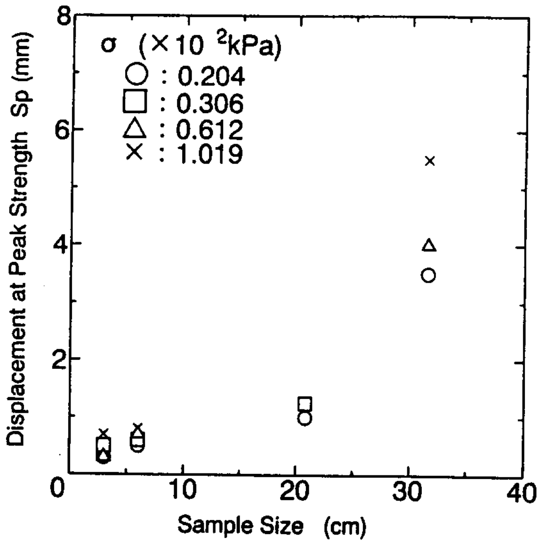

Fig. 8 Horizontal displacement at peak stress versus sample size for HDPE-Toyoura sand

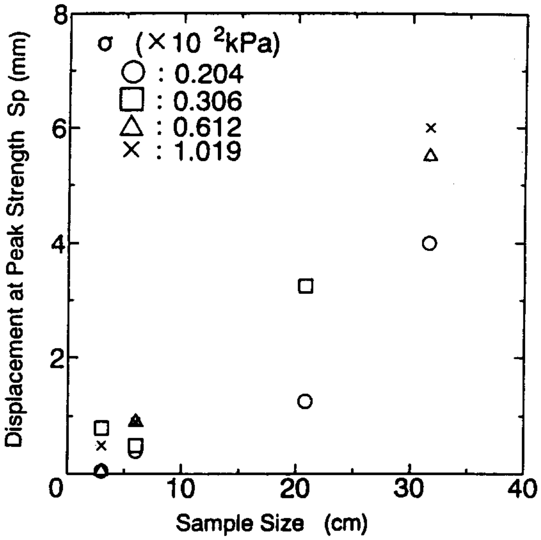

Fig. 9 Horizontal displacement at peak stress versus sample size for HDPE-Inagi sand

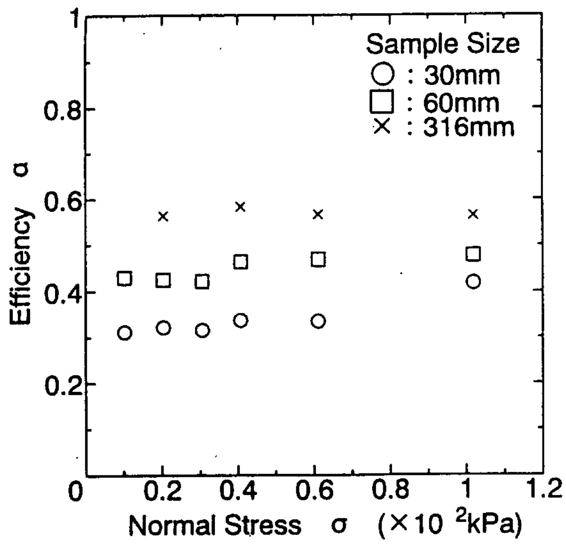

Fig. 10 Frictional efficiency versus sample size for HDPE-Toyoura sand

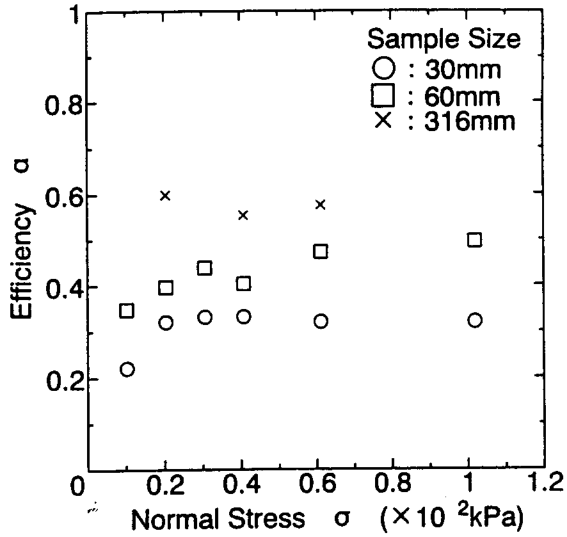

Fig. 11 Frictional efficiency versus sample size for HDPE-Inagi sand

5 CONCLUSION AND ACKNOWLEDGMENT

Shear strength of soil-HDPE interface depends considerably on sample size of sand in direct shear test. The lager a sample size, the lower the shear strength. It is considered for the reason that a progressive failure cause along interface.

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