พารามิเตอร์ของแรงเสียดทานระหว่างทรายกับฐานรากคอนกรีต

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บทคัดย่อ

วัตถุประสงค์ของการศึกษาวิจัยครั้งนี้คือ เพื่อหาค่าพารามิเตอร์ของแรงเสียดทานระหว่างทรายกับฐานรากคอนกรีต โดยทำการทดสอบแรงเฉือนโดยตรงด้วยเครื่องทดสอบแรงเฉือนโดยตรงที่ได้พัฒนาขึ้น เครื่องทดสอบแรงเฉือนโดยตรงที่พัฒนาขึ้นมีขนาดฐานทดสอบแรงเฉือน ขนาด กว้าง ยาว สูง เท่ากับ 30 x 30 x 5 เซนติเมตร ซึ่งมีขนาดใหญ่พอที่ยอมรับและจำลองให้เหมือนกับสภาพจริงของปัญหา

จากผลการทดสอบ ค่ามุมเสียดทานระหว่างผิวสัมผัสจะขึ้นอยู่กับขนาดของเม็ดทราย โดยค่ามุมเสียดทานระหว่างผิวสัมผัสจะมีค่าลดลงเมื่อทรายมีขนาดโตขึ้น โดยมีค่าจาก 35.37 ถึง 29.31 องศาขณะที่ขนาดของทรายอยู่ในช่วงตั้งแต่ 0.15 ถึง 4.75 มิลลิเมตร ในทำนองเดียวกันค่าสัมประสิทธิ์ของมุมเสียดทานจะมีค่าลดลงเมื่อทรายมีขนาดใหญ่ขึ้นโดยมีค่าจาก 0.96 ถึง 0.80 องศาขณะที่ขนาดของทรายอยู่ในช่วงตั้งแต่ 0.15 ถึง 4.75 มิลลิเมตร

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Friction Parameters of Interface between Sand and Concrete Foundation

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Abstract

The objective of this research is to find the friction parameters of interface between sand and concrete by carrying out the direct shear test with the developed large-scale direct shear equipment. The developed large-scale shear device has a lower shear box size of width x length x height be 30 cm x 30 cm x 5 cm which is large enough to simulate the real condition.

The test results showed that the interface parameters between sand and foundation concrete depend on grain size of sand. It was found that the angle of interface friction decrease when the grain size of sand increase. And the angle of interface friction between sand and concrete foundation was decreased from 35.37 to 29.31 degrees while grain size of sand increased from 0.155 mm to 4.75 mm. The efficiency, in terms of ratio of interface friction angle to friction angle of only sand, also showed the decreasing trend when the grain size of sand increase. The value decreased from 0.96 to 0.80 while grain size of sand increased from 0.15 mm to 4.75 mm.

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1. Introduction

Friction between soil and foundation structures often plays an important role in geotechnical engineering structures such as foundation, piles, reinforced earth, retaining wall etc. Because friction is not statically determinant in many of structures, one needs to know not only the friction parameter of soil but also the friction parameter between the interface of soil and structures. It is basic know ledge in order to analyze soil stability problems such as bearing capacity, slope stability and lateral pressure on retaining structures. Based on direct shear tests on interface between various soil and their construction materials, example, concrete, steel, wood etc., Potyondy [1], Brummund and Leonards [2], Acar et al [3] had been studied the friction parameters of interface. More researches of interface had studied in the field of soil and geosynthetics by Seed et al [4], Byrne et al [5], Fishman and Pal [6] and Ling [7]. Koerner [8] pointed out that most results reported for soil-geosynthetic interaction are based on the peak strength. In reaching the residual state, a large shear displacement should be required. Therefore, a shear box larger than that used in the conventional direct shear testing of soil was recommended. ASTM D 5321-92 [10] specifies a shear box with plan area 30 cm by 30 cm.

The objective of the present paper is to quantify the effect of soil grain size on interface between sand and foundation concrete using the developed large scale direct shear test equipment.

2. Testing program and materials

2.1 The developed large-scale direct shear test equipment

Fig. 1 shows the developed large-scale direct shear test equipment which each parts of equipment can be removed and reconstructed. This equipment are composed of the H-beam structures with size 125 x 125 x 6.5 x 9 mm, two 10 ton-hydraulic jacks with size diameter 10 cm length 45 cm, shear box with capable of housing a soil specimen of plan area 30 cm by 30 cm, and a 10 - ton proving ring. The designed shear box has two separate boxes, first, the upper movable box with housing a soil specimen of plan area 30 cm by 30 cm and 7.5 cm in height, second, the lower fixed box with same plan area and 5 cm in height.

2.2 Material Used

Sand used in this experiment were taken from a general river deposit sand. It has properties: 0.1-0.3 % moisture content, 2.60 specific gravity, and SP type from Unified Soil Classification system. Sand samples were classified into 5 range sizes: first, passing no. 4 sieve and retaining on no. 8 sieve, second, passing no. 8 sieve and retaining on no. 16 sieve , third, passing no. 16 sieve and retaining on no. 30 sieve , forth, passing no. 30 sieve and retaining on no. 50 sieve , fifth, passing no. 50 sieve and retaining on no. 100 sieve. Foundation concrete boxes with dimension 30 cm x 30 cm x 5 cm were prepared by using mixing ratio of cement : sand : rock as 1: 2: 3.

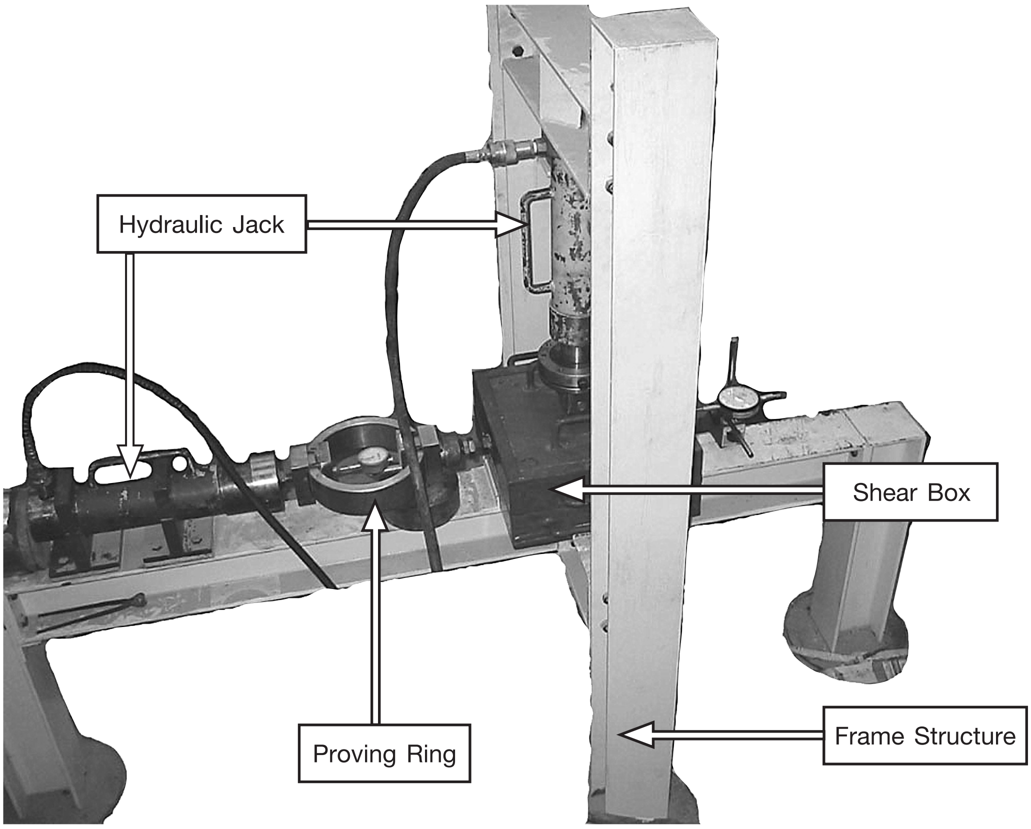

Fig. 1 The developed large-scale direct shear test equipment

The developed large-scale direct shear test equipment was calibrated followed ASTM E74-91 [9] to determine the inherent friction that existed because of the box-box interaction. The true shear force between the sand and foundation concrete were obtained by subtracting the inherent friction from the measured force. Five incremental normal stresses were used for testing.

2.3 Friction parameters of interface between sand and foundation concrete

The procedures of testing were followed the guideline from ASTM D 5321-92 [10] although main areas were applied to analyze the friction interface of soil and geosynthetic. First, the direct shear tests of only sand unclassified grain size were performed by both conventional shear (5 cm by 5 cm) box and developed large-scale shear (30 cm by 30 cm) box. Next, series of direct shear tests for interface between sand and foundation concrete were carried out.

3. Test Results and Discussion

Fig. 2 presents the failure envelopes of sand only for conventional shear box with plan area 5 cm by 5 cm and the developed large-scale shear box. From Fig. 2, the friction angles of sand are 47° and 37° for conventional and developed large-scale shear boxes, respectively. The friction angle value obtained by conventional box was over estimated compared with the value from large-scale box. The large-scale shear box was more reasonable to simulate the real condition and was recommended to find the interface friction parameters. Fig. 3 shows some typical shear stress and strain relationships for the interface between sand and foundation concrete. These observations were obtained from a strain-controlled test. The resisting shear stress increase with shear strain until a failure shear stress was reached. After that, the shear resistance remained approximately constant for any further increase in the shear strain. Direct shear tests were repeated on same size specimens at five incremental normal stresses and results were presented in Table 1. The normal stresses and the corresponding value of maximum shear stresses were plotted on the graph in Fig. 4 from which the interface parameters were determined. The average line in equation (1) obtained from experiment results was followed Mohr-Coulomb failure criteria:

$$\tau_f = C_a + \sigma \tan\delta \quad \text{and} \quad \tau_f = C + \sigma \tan\phi \qquad \textbf{(1)}$$

where C_a and δ are the adhesion and friction angle for the interface, C and ϕ are cohesion and friction angle for the general soil, τ_f is a maximum shear stress, and σ is a corresponding normal stress. From the test results, the grain size of sand affected the interface friction angle but adhesion that close to be zero. When the grain size of sand decreased, the friction angle of interface increased. The results can be explained by that the smaller size of sand will give a higher relative density. And the higher relative density, means higher contact surface area between sand and surface of concrete, and the sand has the higher the friction angle. Fig. 5 shows a variation of interface friction angle with grain size of sand. The trend of interface friction angle decreased from 35.37° to 29.31°, while the grain size of sand increased from 0.15 mm to 4.75 mm. An efficiency, which is the ratio of adhesion to cohesion or the ratio of interface friction angle to friction angle of only sand, was also presented in Fig. 6. The efficiency in term of angle of interface friction showed the decreasing trend when the grain size of sand increased. The values decreased from 0.96 to 0.80 while grain size of sand increased from 0.15 mm to 4.75 mm. And the values were less than unity for all tests and close to unity when the grain size of sand is smallest.

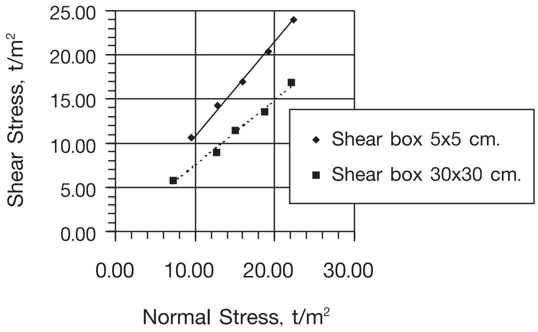

Fig. 2 Failure envelopes of conventional and developed large-scale shear boxes

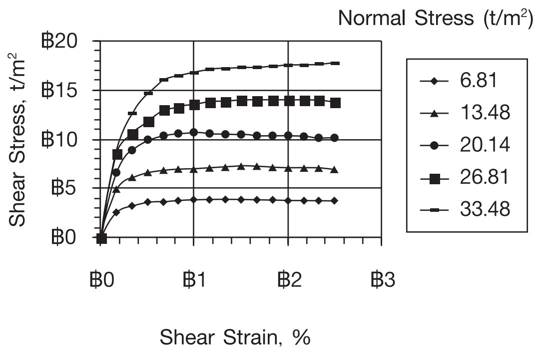

Fig. 3 Typical stress-strain relationships of interface between sand (no.1) and concrete foundation

Table 1 Normal stress and maximum shear stress of different sand grain sizes

Grain Size	Normal Stress (t/m^2)	Maximum Shear Stress (t/m^2)
Sand no. 1	6.46	3.80
Passing no.4	12.72	7.22
Retaining no.8	18.99	10.68
(- 4.75 mm + 2.36 mm)	25.26	14.01
	31.52	17.77
Sand no. 2	6.46	3.63
Passing no.8	12.72	8.65
Retaining no.16	18.99	11.15
(- 2.36 mm + 1.18 mm)	25.26	15.13
	31.52	17.55

Grain Size	Normal Stress (t/m^2)	Maximum Shear Stress (t/m^2)
Sand no. 3	6.46	5.19
Passing no.16 Retaining	12.72	9.42
no.30	18.99	13.06
(- 1.18 mm + 0.60 mm)	25.26	16.34
	31.52	20.14
Sand no. 4	8.33*	6.14
Passing no.30	15.86*	11.15
Retaining no.50	22.12*	14.78
(- 0.60 mm + 0.355 mm)	25.26	18.24
	31.52	22.22
Sand no. 5	8.96*	7.52
Passing no.50	15.23*	10.55
Retaining no.100	21.50*	14.27
(- 0.355 mm + 0.15 mm)	27.14*	18.68
	32.78*	24.21

*higher normal stress from original setting

4. Conclusion and recommendation

A series of direct shear test were conducted on the interface friction between sand and concrete foundation using the developed large-scale direct shear test equipment. The results indicated that the friction angle of interface was affected with grain size of sand. The interface friction angle decreased when grain size of sand increased. This research limited to only the case of interface between foundation concrete and sand. Further research should be extended to different interface such as sand and steel structure, sand and wood, clay and sand, clay and foundation concrete etc.

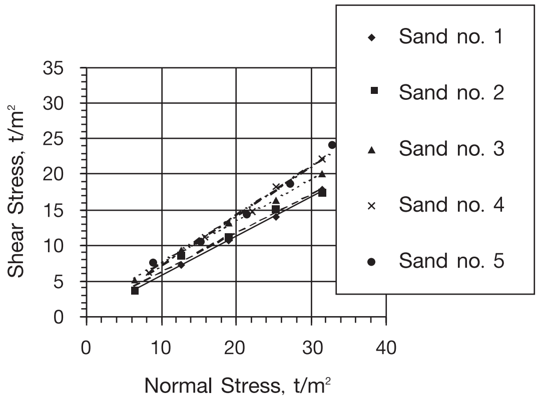

Fig. 4 Failure envelopes of different grain sizes of sand

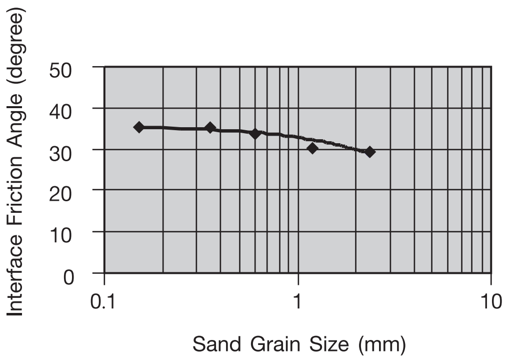

Fig. 5 Variation of interface friction angle with sand grain size

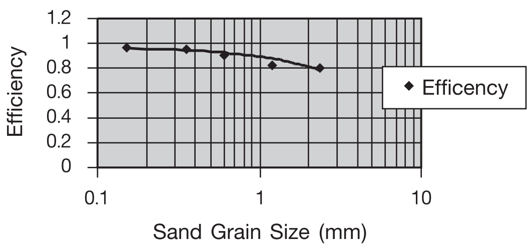

Fig. 6 Efficiency of sand and foundation concrete

Moisture content of sand in this study was keep constant for all tests; imply that the effect of moisture content of sand should be further studied. The effect of roughness surfaces between concrete and sand and the effect of sand swelling are also more deeply understood.

5. Acknowledgement

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