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Behavior of Reinforced Sand in Direct Shear

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1. INTRODUCTION

Direct shear is one of the suitable methods to study the failure mechanism of reinforced soil. A series of direct shear tests on reinforced sand were performed to investigate the interaction between sand and reinforcement, in particular on the dilatancy of reinforced soil.

2. TEST DEVICE

A newly developed direct shear device was used (Fig 1). The main features are: a) the lower box is fixed while the moving box (upper) is prevented from rotating and moving vertically; so the opening between the two boxes is kept constant during each test; b) the load cell that measures the total vertical pressure on the shear plane, installed just above the specimen; c) constant volume test, as well as constant pressure test, can be performed within a given accuracy by means of a computer controlled test procedure.

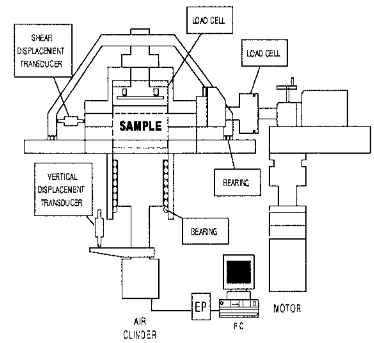

Figure 1 Direct shear device

The specimen was 60mm in diameter and 20mm high. Air-dried Toyoura sand was used. The density was controlled by air pluviation and a little tapping when necessary. The opening between the upper and lower boxes was 0.5 mm. Because of a slow response of the EP (electricity-pressure) transformation, a slow shear speed of 0.05~0.1mm/min was used for satisfactorily constant pressure or constant volume control. Brass strip(s) with different thickness and different surface roughness were used as reinforcement.

3. TEST RESULTS

Constant pressure tests— Dense specimens with a void ratio $e \approx 0.6650$ were sheared under vertical pressure $\sigma=100$ KPa. Two kinds of sand-glued 20mm long brass trip were used; one was 0.1mm thick, 6mm wide, 5 strips in a row; and the other one was a single strip of 0.4mm thick, 7.5mm wide. Both had the same total cross-sectional area, or the longitudinal stiffness, but with different surface areas and bending stiffnesses. Its surface was made either nearly perfectly rough (sand-glued) or smooth. Effects of reinforcement on the strength are noticeable, as can be seen from Figs.2 and 3, The effects are not significant, however, because the reinforcement could not be firmly embedded due to the small thickness of specimen. It is seen that under otherwise the same conditions, the reinforcing effects are larger with the rough reinforcement

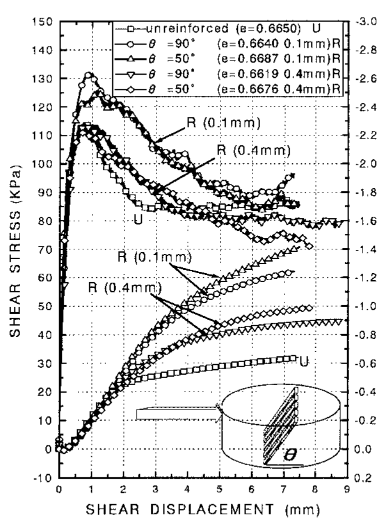

Figure 2 Influence of reinforcement angle and dimensions (rough strips)

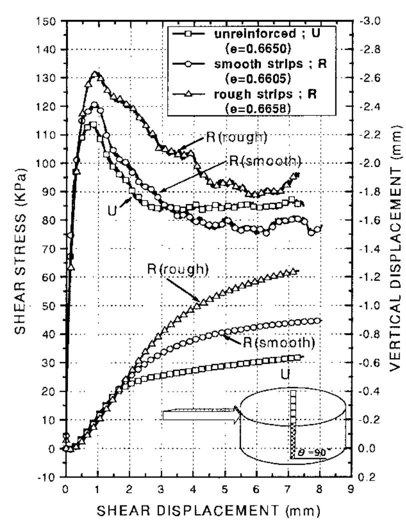

Figure 3 Influence of reinforcement roughness (0.1mm thick strips)

Key words: Direct shear, Reinforcement, Dilatancy, Shear band

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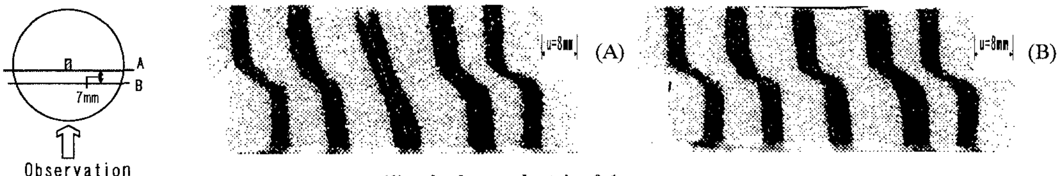
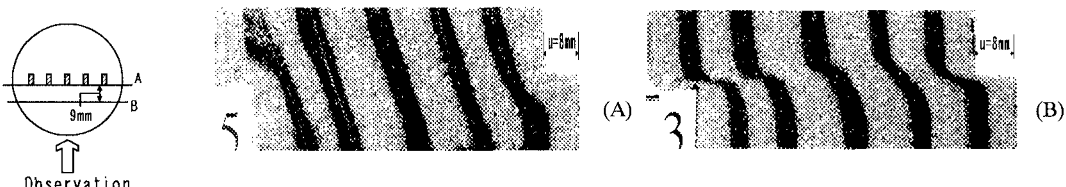


(1) single rough strip 0.1mm



(2) five rough strips 0.1mm

Fig 4 Deformation pattern of reinforced sand(θ =90° e$\approx$0.800)

and with the reinforcement having a larger surface area. The influence of reinforcement orientation θ was analyzed by Jewell [1], and it was concluded that the reinforcement orientation parallel to the principal tensile strain would give rise to the maximum rate of strength increase. Tests with reinforcement oriented close to the principal tensile direction (θ=50°) were also performed in the present study. Probably because of the small size of specimen, no obvious influence of orientation was found.

It is also seen from Figs.2 and 3, the dilatancy became larger by reinforcement, and the dilatancy was larger with the increase in the reinforcing effects on the strength. It is usually considered that the reinforcement restricts the volume increase of sand. The results from triaxial and plane compression tests at constant lateral stress on horizontally reinforced sand agree with the above , but direct shear test results always show the opposite[1],[2]. The authors consider that the intrinsic dilatancy property of reinforced sand is masked in the triaxial and plane strain compression tests, because large compressive strains result from a large increase in pressure level on potential shear bands arising from reinforcing effects. On the other hand, such intrinsic dilatancy property of reinforced sand can be observed in direct shear tests at constant pressure. The pictures taken after two tests(Fig.4) show the deformation patterns of the two cross-sections (A) close to the reinforcement edge; and (B) a 7mm-9mm apart. Free shear banding is restricted by reinforcement, and deformation is more diffused at locations closer to the reinforcement. The inclusion of reinforcement causes a larger volume of sand to deform and dilate, resulting from a wider shear zones when approaching failure. This is a mechanism of the significant dilatancy of reinforced sand in direct shear.

Constant volume tests—To prove the large dilatancy potential of reinforced sand, a series of constant volume tests were performed. Considering the low load capacity of the test device, loose sand (e$\approx$0.8000) was used under low initial vertical pressure (σ_0=20 KPa) . Reinforcement was a single to five 0.1mm-thick sand-glued brass strip(s). Shear and vertical stresses are plotted against shear displacement in Fig 5. Even a single strip exhibited noticeable effects on the shear and vertical stresses. The peak stress and the shear displacement to attain the peak stress increased greatly.

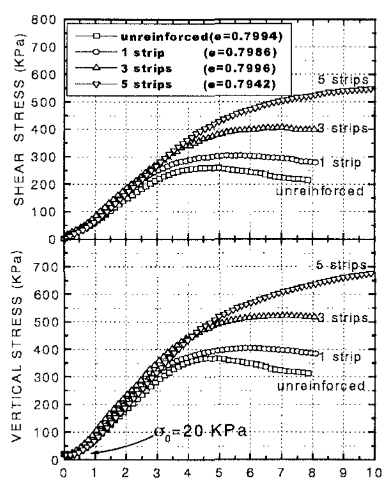


Fig 5 Stress changes in constant volume tests

4. CONCLUSIONS

The following conclusions can be drawn :

(1) The inclusion of reinforcement caused a lager volume of sand to deform and dilate resulting from wider localized zones.

(2) The peak stress and the shear displacement to attain the peak stress increased in constant volume tests on reinforced sand.

REFERENCES

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[2] Gunther E. Bauer and Yijun Zhao (1993), Evaluation of shear strength and dilatancy behavior of reinforced soil from direct shear tests, Geosynthetic Soil Reinforcement Testing Procedures, ASTM STP 1190, 138-151