III-389 Evaluating Different Geosynthetics for Reinforcing Cohesive Soil Mass

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1. INTRODUCTION

Due to its low cost, geosynthetic-reinforced soil walls (GRSW) have gained wide acceptance for replacing the conventional retaining wall and Reinforced Earth/Terre Armee. However, similar to the Reinforced Earth, most GRSW are backfilled with good quality cohesionless soil, which accounted for the largest portion of the total cost. The utilization of poor quality on-site soils, which may be cohesive and even near saturated, would result in a more economic structure.

In this study, three different types of geosynthetic, each of different mechanical and hydraulic properties, were evaluated for their priority in reinforcing the cohesive soil. The performance of an unit cell of geosynthetic and cohesive soil under drained, undrained and partially drained shearings is herein reported.

2. REVIEW OF PREVIOUS STUDIES

It has been highlighted in the previous studies that the conventional triaxial/plane strain testing procedure, which consolidates isotropically the soil-geosynthetic specimen, is inappropriate for studying the mechanism of soil reinforcement (Ling, 1992; Ling and Tatsuoka, 1993). The reinforcement effect is essentially underestimated because the geosynthetic embedded in it was compressed so that it cannot function effectively as a tensile reinforcement upon shearing.

It was reported that for a soil mass of Kanto Loam reinforced with different types of geosynthetic, an initial stress ratio, $K=\sigma'_{30}/\sigma'_{10}=0.3$, corresponded closely to a propped wall without mobilizing significant tensile strain in the geosynthetic. When a smaller ratio, say $K=0.15$, was used, tensile strain was mobilized in the geosynthetic during consolidation, and the situation corresponded to an incrementally constructed wall. The results reported in this study were limited to the case with $K=0.3$.

3. SOIL AND GEOSYNTHETICS

Kanto loam, a volcanic silty clay, was used. Its in-situ water content was close to 100 percent. The nonwoven geotextile, nonwoven-woven composite geotextile, and grid, were selected for this study. The composite geotextile has a woven layer interbedded between two nonwoven layers, which were manufactured from polypropylene. The grid was manufactured from polyester fibers.

The mechanical and hydraulic properties of the nonwoven and composite geotextiles have been studied in details (e.g., Ling et al., 1992,1993). Table 1 summarized the initial stiffness and strength of these three geosynthetics. The grid does not conduct flow in its plane whereas the nonwoven and composite geotextiles gave a coefficient of in-plane hydraulic conductivity of about 10^{-1} cm/sec under unconfined condition.

Table 1. Mechanical properties of geosynthetics.

Geosynthetic	Initial Stiffness	Strength
Nonwoven	4.7	1.44
Composite	23.0	2.12
Grid	113.9	19.7

(unit: tf/m)

4. TESTING CONDITIONS

The unit cell of soil and geosynthetic was prepared by compaction in a mold and then installed to an automated plane strain testing device and fully saturated. It allowed anisotropic consolidation to be performed prior to undrained, drained or partially drained shearing. The initial minor principal stress was selected as $\sigma'_{30}=0.5\ kgf/cm^2$ (i.e., $\sigma'_{10}=1.667\ kgf/cm^2$). In the partially drained tests, drainage was allowed through the plane of geosynthetic at the mid-height of specimen (Fig. 1).

Consolidation of specimen was conducted at a constant axial strain rate of 0.01 percent per minute and then delay consolidated for 8 hours after having attained the required effective stresses. The drained and undrained shearings had a similar strain rate, but in the partially drained tests, it was increased to 0.07 percent per minute. Details of the testing program are given in Ling (1992).

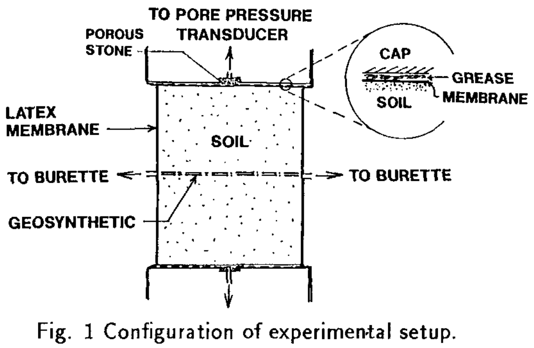

Fig. 1 Configuration of experimental setup.

5. TEST RESULTS AND DISCUSSIONS

Figs. 2(a) to (c) gave the deviatoric stress-axial strain relationships of the soil mass reinforced with three different geosynthetics under drained, undrained and partially drained conditions, respectively. The results of unreinforced soil were included for comparison.

The reinforcement effect was directly a consequence of lateral restraining effect offered by the geosynthetic (Fig. 3). The lateral restraining effect was more noticeable when a geosynthetic having a higher stiffness/strength was used, which restrained the lateral deformation of the soil mass and therefore contributed a larger mobilized stress as shearing proceeded.

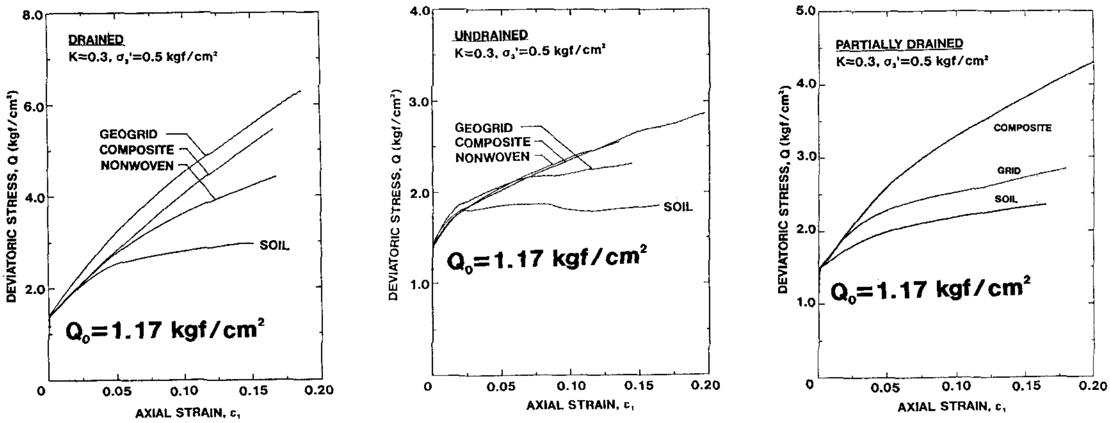

Fig. 2 Stress-strain relationships during (a) drained, (b) undrained, and (c) partially drained shearings.

In the undrained test, due to the build-up of excess pore water pressure, which was greater in the reinforced specimen when compared to the unreinforced specimen (Fig. 4), the lateral restraining effect was 'killed' so that the mobilized stress at the initial stage of shearing was similar or even smaller in the reinforced soil mass when compared to the unreinforced soil mass. The reverse occurred as subsequent shearing resulted in a greater mobilized lateral strain in the geosynthetic. It was of interest to see that the grid reinforced specimen, which rendered the largest strength in drained test, gave the lowest value among the three geosynthetics in undrained tests.

The partially drained tests simulated more closely the field condition in which the excess pore water pressure was allowed to dissipate from the unit cell as it was loaded, particularly when a geosynthetic with adequate in-plane hydraulic conductivity was used. The mobilized stress in the soil mass reinforced by the grid was much smaller than that reinforced by the composite geotextile.

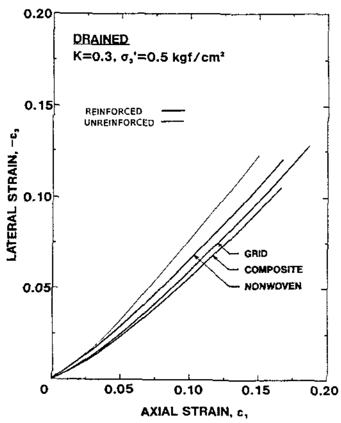

Fig. 3 Lateral tensile strain during drained shearing.

6. CONCLUSIONS

This study led to the conclusion that cohesive soil can be used as backfill of the reinforced soil walls with the aid of permeable geosynthetics. The composite geotextile, which is stiffer and stronger than the nonwoven geotextile, and has a greater in-plane hydraulic conductivity than the grid, is regarded as the most acceptable material for this purpose.

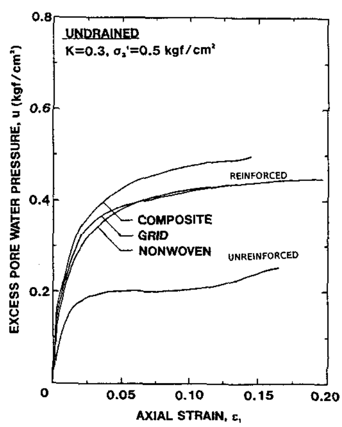

Fig. 4 Excess pore water pressure during undrained shearing.

7. REFERENCES

/1/ Ling, H.I., Wu, J.T.H., and Tatsuoka, F. (1992). Short-Term Strength and Deformation Characteristics of Geotextiles under Typical Operational Conditions, *Geotextiles and Geomembranes*, 11(2), pp. 185-219.

/2/ Ling, H.I., Tatsuoka, F., and Wu, J.T.H. (1993). Hydraulic Conductivities of Geotextiles under Operational Conditions, *Geotextiles and Geomembranes*, 12(4).

/3/ Ling, H.I. (1992). *Performance of Geosynthetic-Reinforced Cohesive Soil Mass at Plane Strain Compression*, Doctoral Thesis, University of Tokyo, December.

/4/ Ling, H.I. and Tatsuoka, F. (1993). Laboratory Evaluation of a Nonwoven Geotextile for Reinforcing On-Site Soil, *Proc. Geosynthetics '93 Conference*, Vancouver, B.C., Canada, pp. 533-546.