MECHANICAL MODEL AND EXPERIMENTS RELATED TO DEFORMATION OF REINFORCED SOIL WALLS

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ABSTRACT: To study the deformation of geotextiles put under ground, we estimate the strain distribution on geotextiles by using two mechanical models and, in this case, carry out a laboratory pull out test used in geotextiles of non-woven fabric. As a result, the values calculated by mechanical models approximately agreed with the experimental values. We have already reported these results[1,2]. As a next step, we carried out a laboratory experiment in order to obtain the actual deformation of a reinforced soil wall and we examined if the mechanical model which we propose could also apply to the prediction of the deformation of a reinforced soil wall. The deformation of a reinforced soil wall is obtained by integrating the strain distribution on the geotextile. As aresult of our investigation, the calculated values approximately agreed with the actual deformation of the reinforced soil wall. These results can be utilized for the design method of reinforced soil walls taking into account deformation.

1 INTRODUCTION

The deformation distributions of the geotextiles are not a constant when the pull out force affects a geotextile put under ground. Research about deformation by pull out tests has been reported by many researchers. This summary is a written introduction of a paper reported by Gurumg and Iwao[3]. We have also examined deformation when a pull out force acts on a geotextile under ground,
As a result, the trend of deformation distributions by analysis agreed approximately with experimental results[2]. However, until now, study results have not been applied to the analysis of the deformation of reinforced soil walls or other reinforced soil structures used in geotextiles, because studies have been limited to pull out properties of geotextiles. Then, as the next step, we estimated if our study can apply to the prediction of the deformation of reinforced soil walls. The deformation volume of reinforced soil walls was obtained by integrating the strain distribution on the geotextile. As a result, the value calculated by the mechanical model agreed approximately with the deformation of the reinforced soil wall. These results can be utilized for the design method of reinforced soil walls taking into consideretion deformation.

2 EXPERIMENTAL PROCEDURE

To compare the actual deformation of a reinforced soil wall with analytical result, the experimental equipment which model reinforced soil wall was made by using an earth tank as shown in figure 1. the dimension of earth tank is 56cm wide, 100cm long, 50cm height. The reinforced soil wall was made by putting wall panels one on top of the other. The wall panel is made from wood and the width, height, thickness is 10cm, 55cm, 1.5cm. Also, the wall panels put the geotextile. The geotextile used is a spun-bounded 100% polypropylene non-woven fabric. It is possible that we obtain a large strain even in the model

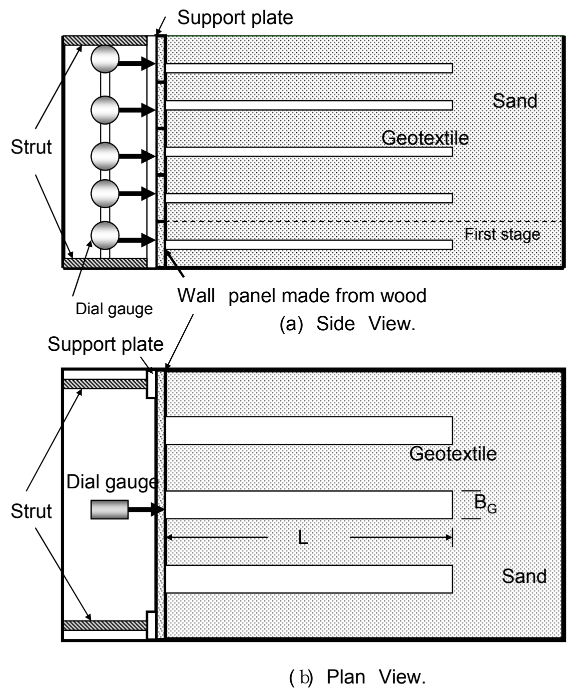


Fig. 1 Experimental Equipment of Reinforced Soil Wall

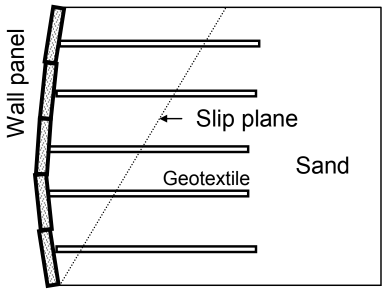


Fig. 2 Deformation of Reinforced Soil Wall

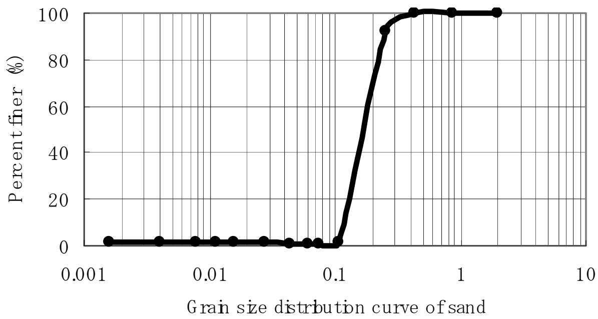


Fig.3 Grain Size Distribution Curve of Sand

test used earth tank, because a Young modulus of non-woven fabric is small. This is the reason why we used the non-woven fabric to the geotextile. As above mentioned, the geotextiles was attached at the center of the panel wall by the wood screw, and we used the geotextiles of 2 kinds of size. The dimension is 0.1cm in thickness and width × length is, 10cm × 55cm, 5cm × 55cm. We attached the geotextile of same size for a panel wall. Attaching number of sheet are 2 types. One type put 3 sheets and other 2 sheets (refer to Fig. 1). A work procedure of the reinforced soil wall are as follows.

At first, we installed support-plate and struts on both sides of the earth tank. Next, we put a panel wall of the first stage as shown in Fig. 1(a), then, sand was gradually put in. when height of sand reaches at a position of the geotextile which attached panel wall, geotextile was laid on the sand. After, we laid sand to the height of the wall panel. By the similar method, we piled up the wall panel to the fifth stage. The combination between the wall panels has not been done. A height of wall panel 5 stages (H) is 50cm. Next, we installed the dial gauge to measure the deformation of the reinforced soil walls as shown in figure 1(a) (b). After the reinforced soil wall was completed, we removed the struts on both side in a moment, The supports of the support-plate was canceled by this. The wall panels of the reinforced soil wall were deformed outside as shown in figure 2. The deformation volumes of each wall panel of reinforced soil wall were measured by dial gauges. Sand used for this experiment is Toyoura sand. The grading curve is shown in figure 3. The relationship between an internal frictional angle and initial void ratios of the sand obtained by the single shear test is shown in figure 4. A Young modulus of the geotextile was obtained from a gradient of straight line of tensile stress-strain curve. The value was 5500kN/m^2.

3 MECHANICAL MODEL BETWEEN THE GEOTEXTILE AND SOIL PUT UNDER GROUND

To obtain the deformation of a geotextile put under ground, we have studied tensile stress distribution of the geotextile by two mechanical models1[1,2]. As a result, we have been able to evaluate the tensile stress distribution of geotextiles laid under ground by two mechanical models. Then, we considered whether the deformation of geotextiles can be obtained by integrating the strain distribution. From this idea, the two mechanical models which we proposed were utilized for the prediction of deformation volume of reinforced soil walls. In this paper, the deformation of reinforced soil walls was examined by the mechanical model shown in figure 5, in which boundary condition is simple within two mechanical model.

From the equilibrium condition of this model, the differential equation is expressed as follows:

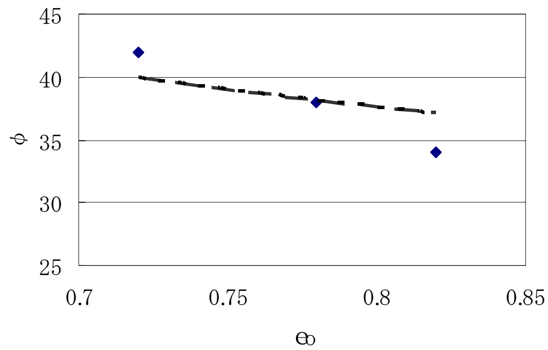


Fig. 4 Relationship between eo and Φ

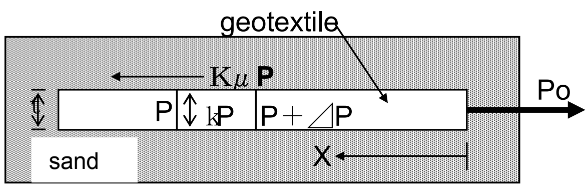


Fig. 5 Mechanical Model for Analyzing Distribution of Tensile Strength

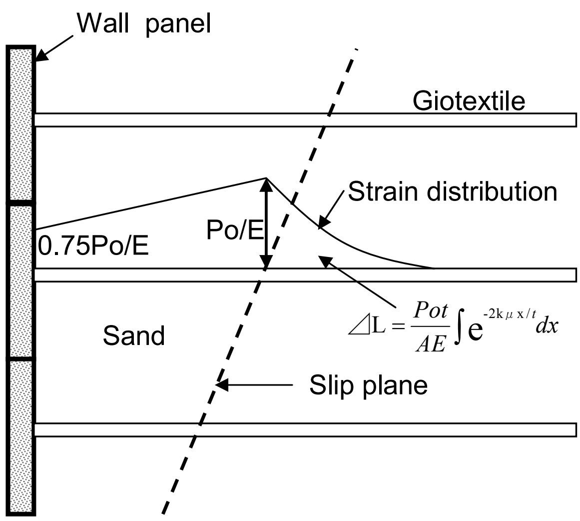


Fig. 6 Strain Distribution of Geotextile put under Soil

$-dPt = 2k\mu Pdx$ (1)

t ,thichness of geotextile

Solving with the boundary conditions of

X=0 P=Po, X=L P=0

We obtained the following:

$$P = P_0 e^{-2k\mu l/t} \quad (2)$$

In addition, we obtained the strain, when equation (2) is divided by a Young modulus (E) of the geotextile from Hooke's law.

$$\varepsilon = P_0 e^{-2k\mu l/t} / AE \quad (3)$$

A: cross section area of geotextile

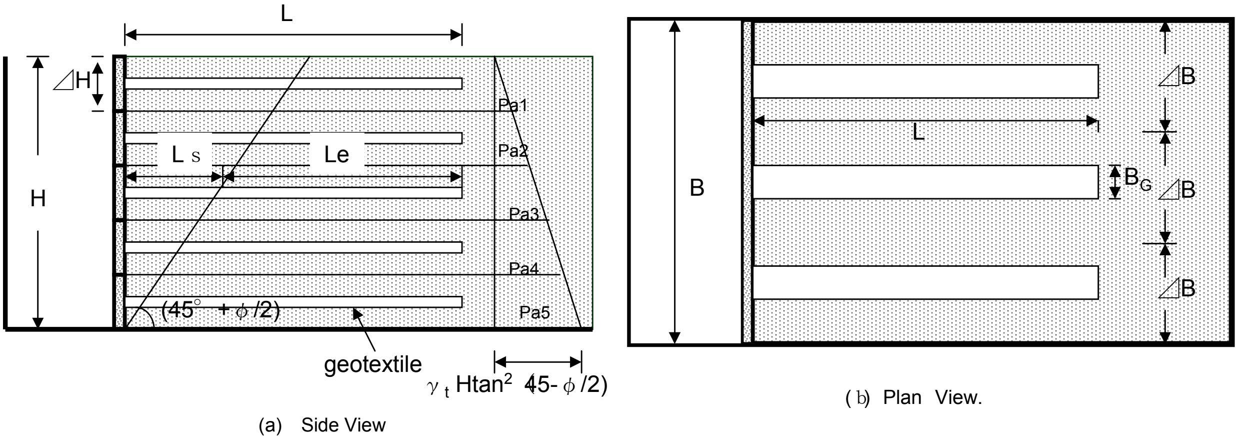


Fig. 7 Arrangement of Equipment for Analyzing the Deformation Distributions of Geotextile

From research up to now, the strain distribution of a geotextile under ground which is attached to a wall panel is shown in figure 6. As shown in this figure, the strain distributions on the right side and left side from the plane are different, and the strain reaches a maximum at the position where the slip plane passes the geotextile. In this research, equation (3) was applied for the strain distribution on the right side. And, trapezoid strain distribution which many researchers have proposed was applied for the strain distribution of the left side.

The maximum strain of the trapezoid becomes Po/AE at the point where the slip plane passes the geotextile and the minimum strain becomes 0.75Po/AE at the wall panel as shown in figure 6. The strain distribution between the maximum strain and minimum strain becomes a straight line. The trapezoidal area becomes the deformation volume of the geotextile on the left side from the slide plane. Thus we obtained the following equation.

$$\Delta Ls = \frac{(0.75Po + Po)Ls}{2EA} \quad (4)$$

⊿Ls: deformation volume of the geotextile on the left side from the slide plane

A: cross section area of geotextile

Ls: length of the geotextile from the wall panel surface to slip plane (refer to figure 7(a)) .

Po: maximum pull out force

Next, we tried to obtain the deformation volume of the part on the right side of the slip plane. We considered that it is possible to show the strain distribution on the right side by the above mentioned equation 3. Therefore, the deformation volume of the geotextile is obtained by integrating equation 3. The deformation volume (⊿Le) can be shown as follows,

$$\Delta Le = \frac{P_o t}{2\,EAk\mu}\left(1 - e^{-2k\mu\,Le}\right) \quad (5)$$

⊿Le. deformation volume of geotextile on the right side from the slip plane

Le: L-Ls

By adding equation 4 and equation 5,

the whole deformation volume of the geotextile can be shown as following.

⊿L=⊿Ls+⊿Le (6)

Next, we try to obtain the deformation volume of the reinforced soil wall by using equation 6.

4 DEFORMATION VOLUME OF A REINFORCED SOIL WALL

We tried to obtain the actual deformation volume by the experimental equipment shown in figure 1 in order to examine the applicability of equation 6. After wards, we compared the deformation volume calculated by equation 6 with the actual deformation volume.

To use equation 6, it is necessary to know the maximum pull out force (Po) of equation 4 and 5. Next, we examined the maximum pull out force (Po).

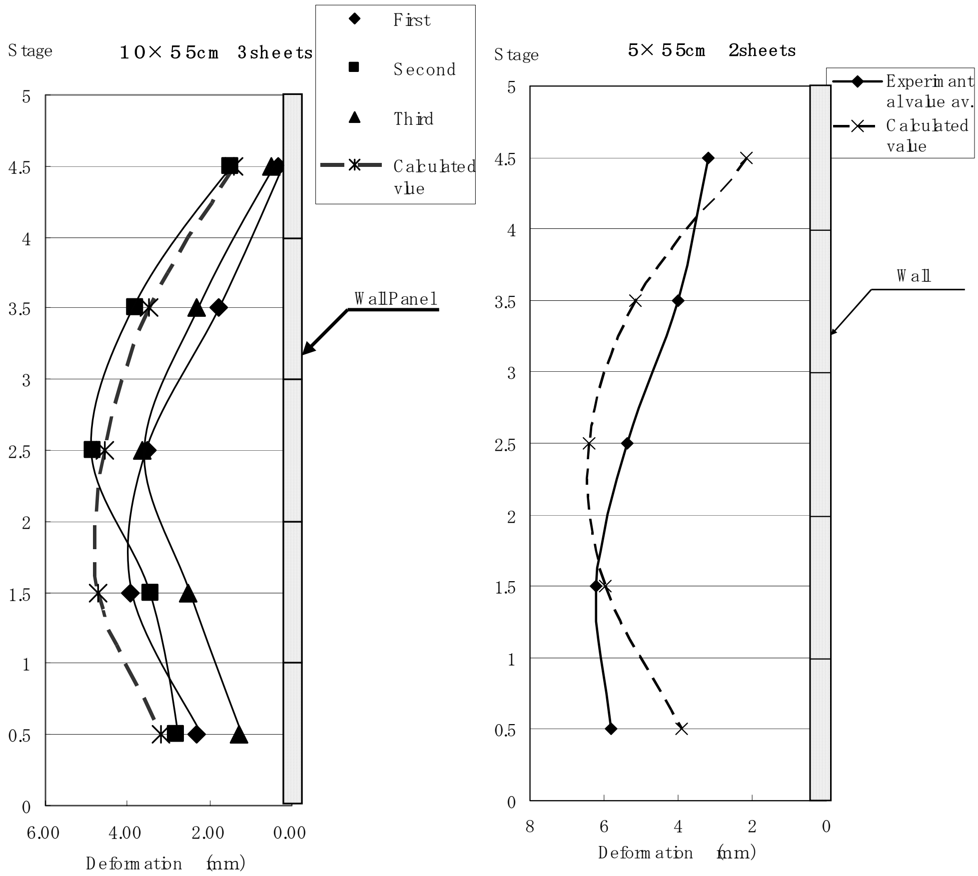
4.1 *Maximum Pull Out Force Acting on a Geotextile*

To examine the maximum pull out force which acts on a geotextile, we confirmed the shape of the slip plane by an experiment on the model reinforced soil wall. The confirmation was carried out by laying the thin coloured sand layers.

As a result, the slip plane became almost a straight line from this result, to obtain the maximum pull-out force, we considered that the Rankine earth pressure theory could be used. The schematic figure of the Rankine earth pressure distribution is shown in figures 7(a). By multiplying the earth pressure between ⊿H by ⊿B shown in figure 7(b), the maximum pull out force that acts on a sheet of geotextile is obteined.

4.2 *Deformation of Reinforceed Soil Wall*

Deformation volume ⊿Ls of the geotextile on the left side from the slide plane was calculated by equation 4. ⊿Le on the right side from the slide plane can be calculated by equation 5. However, values of coefficient K and μ are necessary in order to use this equation. These coefficients k and μ have not yet been clarified. But, we can simply estimate that coefficient k relates to an earth pressure coefficient and that the coefficient μ is the friction between soil and the giotexitile. Then, we calculated ⊿Le



(a) (b)

Fig. 8 compared the actual deformation volume obtained by the experiment with the deformation volume obtained by the calculation

by using the coefficient of an active earth pressure to k and $\mu = \sigma \tan \phi$ (σ :overburden pressure, ϕ :internal friction angle). Consequently, these coefficients could not be used, since ⊿Le becomes a very large value. Then, the value of kμ was obtained by a pull out test. The value of this kμ is in proportion to the overburden pressure. kμ=0.000023σ was obtained. ⊿Le was calculated by using this kμ .

The whole deformation value (⊿L) of the geotexitail at each stage was finally obtained by equation 6.

Next, we compared the actual deformation volume obtained by the experiment with the deformation volume obtained by the calculation. The representative example is shown in figures 8(a) (b). The dotted line in this figure is the calculated values, and solid lines are experimental values. The geotextiles used in case of figure 8 are 10cm wide, 55cm long, and 3 sheets of geotextiles are attached to the wall panel.

First, we examined the deformation volume obtained by the experiment. As shown in figure 8(a), the deformation volume gradually increases from the lower stage to the upper stage, and it reaches maximum near the center.

Then, the deformation volume decreases for the lower stage. The experiment was carried out 3 times under the same conditions. As shown in figure 8, similar results were obtained,

Next, we examine the dotted line of figure 8 (a) which shows the calculation value. As shown in this figure, the calculated value agrees approximately with the actual value.

Next, we examine figure 8(b). The figure is the experimental result when 2 sheets of geotextile are attached to a wall panel.

As shown in this figure, the calculated value agrees approximately with the actual value even in this experiment.

From these results, it is considered that equation 6 can be utilized for the design method of a reinforced soil wall taking into consideration deformation.

5 CONCLUTION

The calculated values by using the mechanical model which we propose approximately agreed with the actual deformation of the reinforced soil wall. From this result, It was possibel to predict the deformation of a reinforced soil wall.

These results can be utilized for the design method of reinforced soil walls taking into account deformation.

6 REFERRENCE

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3) Netra GURUNG and Yushiro IWAO,“Analytical Pull-Out Model for Extensible Soil-Reinforcement“, Japan Geotech Emg., JSCE, No.624/Ⅲ-47, pp.11-20, 1999 June