PREDICTION OF THE CREEP DEFORMATION OF A REINFORCED SOIL WALL

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Abstract: Prediction of the deformation of a reinforced soil wall was attempted using a mechanical model that was proposed and model experiments were also carried out. As a result, calculated values approximately agreed with the actual deformation of the reinforced soil wall. The deformation in this case is from the earth pressures generated in the reinforced soil wall. However, in addition, a reinforced soil wall will have creep deformation, which changes with time. As the next step, the mechanical model was examined to assess inclusion of prediction of creep deformation of a reinforced soil wall and in this case model experiments were also carried out. Consequently, calculated values approximately agreed with the actual creep deformation of the reinforced soil wall. These results can be utilized for design of reinforced soil walls taking into account deformation.

Keywords: reinforced soil wall, creep, deformation, prediction, geotextile, measurement

INTRODUCTION

Research about deformation of a reinforced soil wall has been reported by many researchers. However, the research on the deformation of a reinforced soil wall has not been sufficiently carried out. Therefore, prediction of the deformation of a reinforced soil wall was attempted using a mechanical model that was proposed and model experiments were also carried out. As a result, calculated values approximately agreed with the actual deformation of the reinforced soil wall（Kaga 2004, 2006). The deformation in this case is from the earth pressures generated in the reinforced soil wall. The deformation of a reinforced soil wall is greater than for a concrete gravity retaining wall because the rigidity of a reinforced soil wall is less. Therefore, a reinforced soil wall will have creep deformation that changes with time (Hrle 2006). As the next step, the prediction of the creep deformation of a reinforced soil wall was examined by using a mechanical model proposed by the authors. First actual creep deformation volume was continuously observed for a week by the model experiments. As a result, it was observed that the deformation of the reinforced soil wall continued with time, after the reinforced soil wall was completed. This creep deformation becomes a maximum in the central of the reinforced soil wall, and the whole deformation of the reinforced soil wall becomes a bow. As the next step, a creep deformation test of the geotextiles themselves was carried out in order to estimate the creep deformation of a reinforced soil wall. An isochronal stress-strain chart was produced from the creep deformation test. The gradients of the isochronal stress-strain line decreased with time. The decrease in this gradient was considered as a softening of the Young modulus. Then, it was estimated if the Young modulus can be applied to the prediction of the creep deformation of a reinforced soil wall by the using mechanical model proposed. As a result, the value calculated by the mechanical model agreed approximately with the creep deformation of the reinforced soil wall. These results can be utilized for the design method of reinforced soil walls taking into account deformation.

EXPERIMENTAL PROCEDURE

To compare the actual deformation of a reinforced soil wall with the analytical result, experimental equipment, which modelled the reinforced soil wall was made by using an earth tank as shown in Figure 1. The dimension of the earth tank is 30cm width, 200cm length, 90cm height.

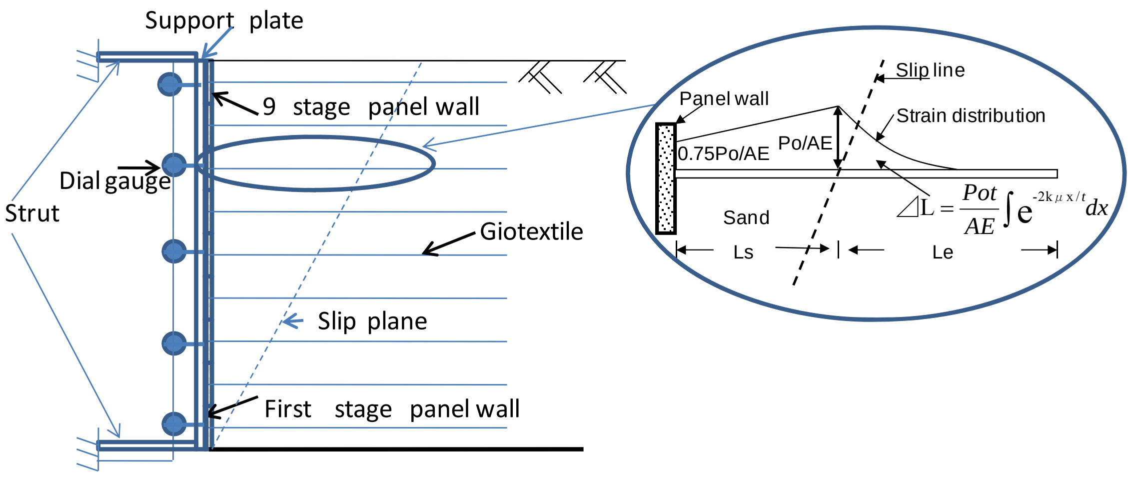


Figure 1. Experimental equipment of reinforced soil wall and strain distribution 0f geotextile put under soil

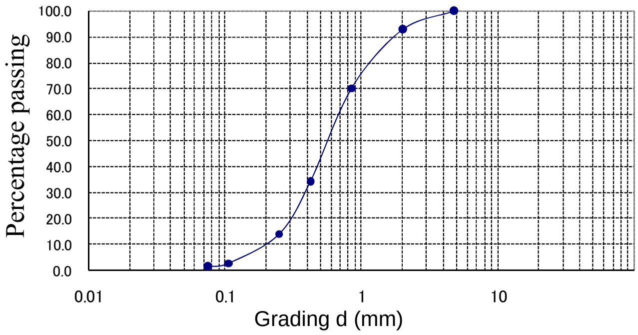


Figure 2. Grain size distribution of sand

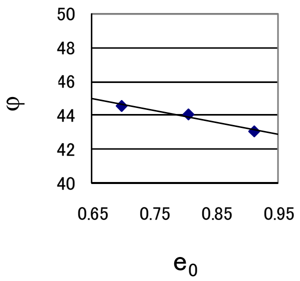


Figure 3. Relationship between e_o and φ

The geotextiles that are used in this experiment are spun-bounded 100% non-woven fabric and polyethylene netron sheet. The Young's moduli of the non-woven fabric and Netron polyethylene sheet were 13,500 and 46,200 kN/m^2 respectively. The type of sand used is coarse sand.
The grading curve is shown in Figure 2. The relationship between the internal friction angle (φ) and initial void ratios of the sand obtained by the single shear test is shown in Figure 3.

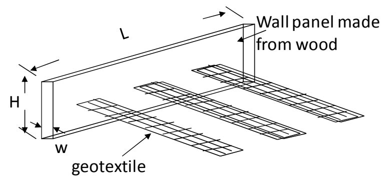


Figure 4. Wall panel

The work procedure for making the reinforced soil wall is as follows. 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 30cm, 10cm, 1.5cm. The geotextiles were attached at the center of the panel wall with wood screws, the dimension is width×length is, 5cmx70cm. Three sheets were attached (refer to Figure 4).

Sand was piled up on the wall panel. Combinations of wall panels were not performed. Next, a dial gauge was installed to measure the deformation of the reinforced soil walls as shown in Figure 1. After the reinforced soil wall was completed, the struts were removed on both sides at once. The support of the support-plate was cancelled by this action. The wall panels of the reinforced soil wall were deformed outside. The deformation volumes of each wall panel of the reinforced soil wall were measured by the dial gauges for a week.

MECHANICAL MODEL TO EVALUATE DEFORMATION OF GEOTEXTILE PUT UNDER GROUND

From research up to now, it has been explained that this proposed mechanical model is utilized for the prediction of deformation volume of reinforced soil walls. For details, refer to reference (Kaga 2004). However, this mechanical model is simply explained in order to obtain an understanding.

It is proposed that the strain distribution of a geotextile under ground is attached to a wall panel as shown in Figure 1. As shown in this Figure, the strain distributions on the right side and left side from the slip plane are different, and the strain reaches a maximum at the position where the slip plane passes the geotextile. Trapezoid strain distribution that 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. 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 the following equation can be obtained.

$$\triangle Ls = \frac{(0.75Po + Po)Ls}{2EA} \qquad (1)$$

$\triangle$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 the slip plane (refer to Figure 1) .
Po: maximum pull out force

Next, it was attempted to obtain the deformation volume of the part on the right side of the slip plane. It is considered that it is possible to show the strain distribution on the right side by the equation shown in Figure 1. This strain distribution resembles the distribution that Netra and Yushiro (1999) were obtained by pulled out test. Therefore, the deformation volume of the geotextile is obtained by integrating equation 3. The deformation volume ($\triangle$Le) can be shown as follows,

$$\triangle Le = \frac{P_o t}{2\ EAK\mu}\left(1 - e^{-2k\mu\, Le/t}\right) \qquad (2)$$

Le is 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 the following.

$$\triangle L = \triangle Ls + \triangle Le \qquad (3)$$

From research up to now, the deformation of the reinforced soil wall could be predicted by equation (3). The deformation is from the earth pressures generated in the reinforced soil wall. However, a reinforced soil wall will have creep deformation, which changes with time.

As the next step, the mechanical model was examined to assess inclusion of prediction of creep deformation of a reinforced soil wall and in this case model experiments were also carried out.

CREEP DEFORNMATION OF A REINFORCED SOIL WALL

An experiment was carried out in which the type of the geotextile was changed in order to obtain creep deformation of a reinforced soil wall. The creep deformation was observed for a week. The representative examples are shown in Figures 5 and 6. These figures show the deformation of the reinforced soil wall attached to a non-woven fabric. The Figure 5 shows the relationship between creep deformation volume and elapsed time. From this figure, it is proven that the reinforced soil wall has produced creep deformation, which transforms with time.

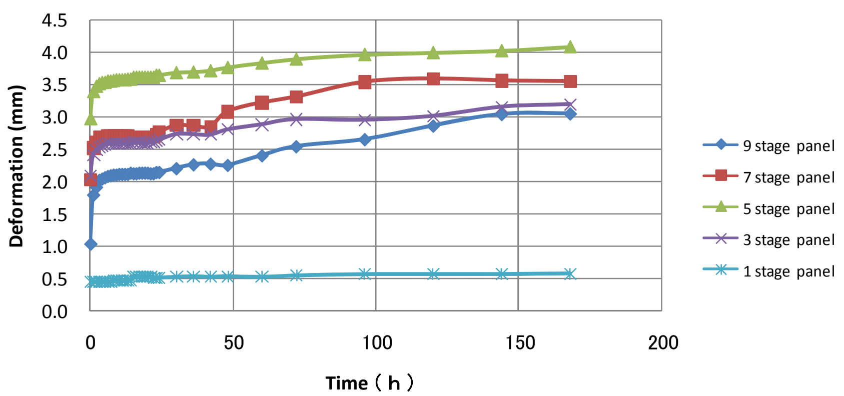


Figure 5. Creep deformation of reinforced soil wall used in non-woven fabric

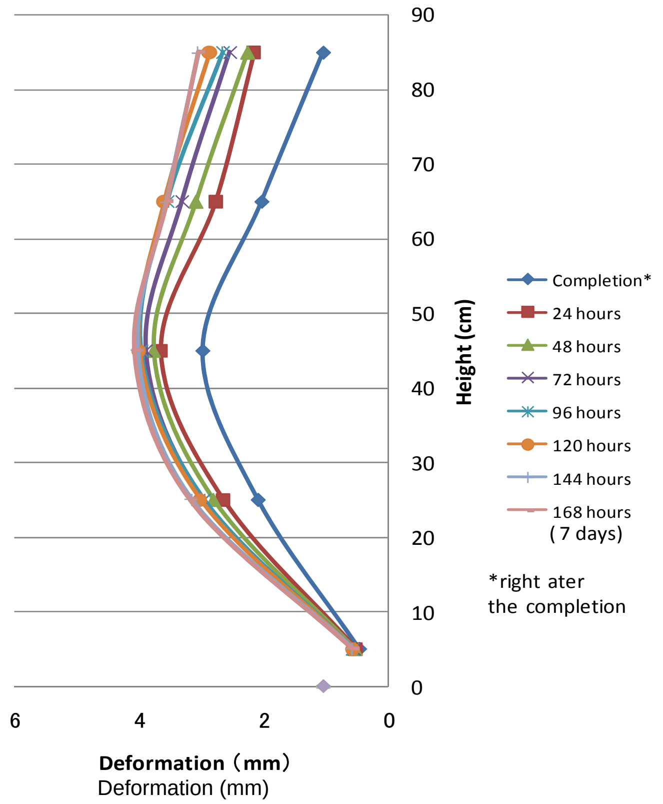


Figure 6. Creep deformation from the upper most stage to the bottom stage panel of a reinforced soil wall used in non-woven fabric

Figure 6 shows the deformation from the upper most stage panel to the bottom stage panel of a reinforced soil wall. The data is the same data as in Figure 5. From this figure, the creep deformation volume can be examined obtained by the experiment. As shown in this figure, the fundamental deformation becomes a maximum near the center. The earth pressure that affects the reinforced soil wall is proportional to the depth from the earth surface. However, these deformation volume are not proportional to the size of the earth pressure. Also, it is shown that creep deformation volume decreases with time. Similar results for reinforced soil wall used in polyethylene netron sheet were obtained.

CREEP DEFORMATION OF THE GEOTEXTAILE MATERIALS

First the creep test of geotextile itself was carried out in order to predict creep deformation of the reinforced soil wall shown in the above-mentioned Figures 5 and 6.

A representative example is shown in Figure 7. This figure shows the relationship between creep deformation volume and elapsed time when using a polyethylene netron sheet. From this figure, it is proven that the polyethylene netron sheet has produced creep deformation with the time.

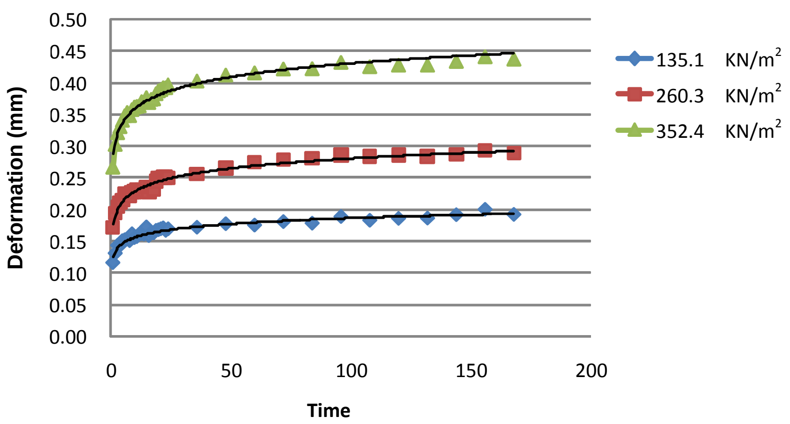


Figure 7. Creep deformation of polyethylene netron sheet

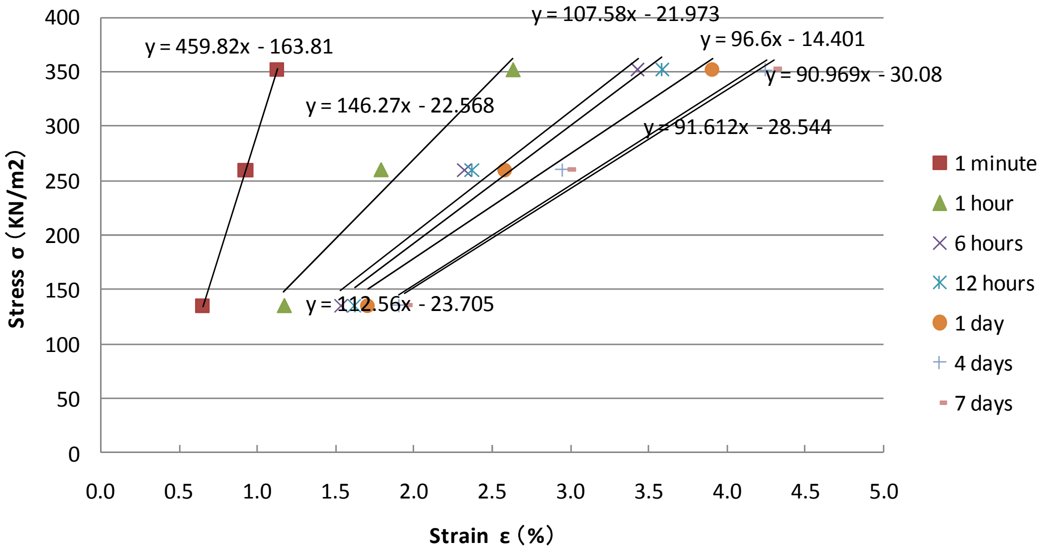


Figure 8. Isochronal stress-strain chart of polyethylene netron sheet

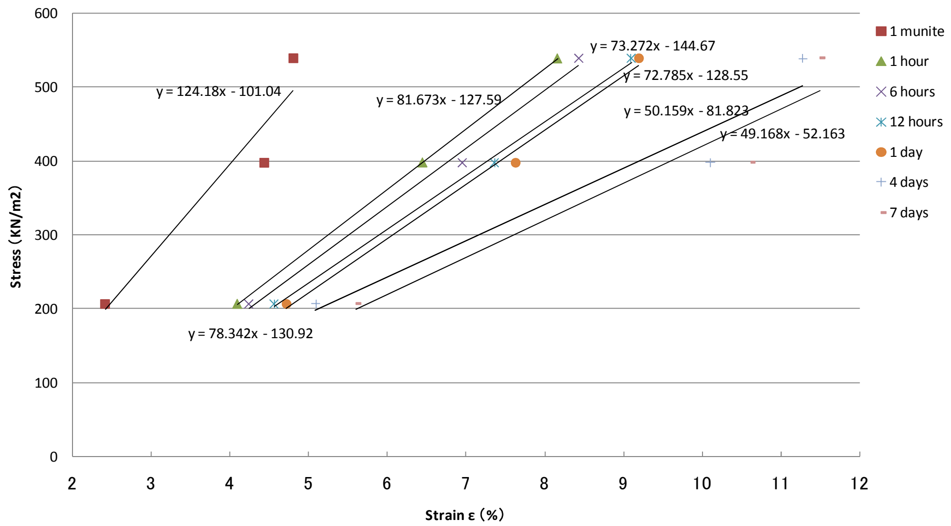


Figure 9. Isochronal stress-strain chart of non-woven fabric

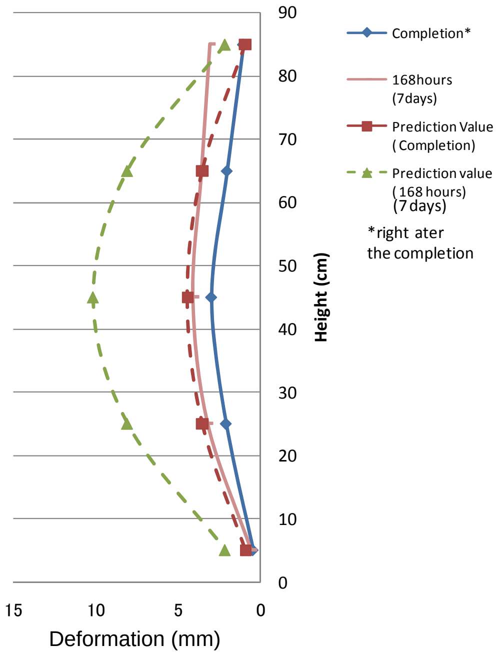
As the next step, an isochronal stress-strain chart is made from the creep deformation test and the isochronal stress was tied in a straight line. The results are shown by the solid lines in Figure 8. The data is the same as in Figure 7.

The gradients of this straight line were noted. It is possible to regard this gradient as the Young modulus, because the relationship between stress and strain is shown. These gradients decreased with time. It is considered that the decrease in this gradient as a softening of the Young modulus. Then, it was estimated if these Young moduli can be applied to the prediction of the creep deformation of reinforced soil walls. Similar results for non-woven fabric were obtained. The results are shown in Figure 9.

PREDICTION OF THE CREEP DEFORMATION OF A REINFOCED SOIL WALL

From research up to now, it was possible to predict the deformation of a reinforced soil wall using a mechanical model. The deformation in this case is from the earth pressures generated in the reinforced soil wall.

Next, it was estimated if a mechanical model proposed can be applied to the prediction of the creep deformation of reinforced soil walls. It was noticed that a Young modulus (E) was included in equation (1) and (2).



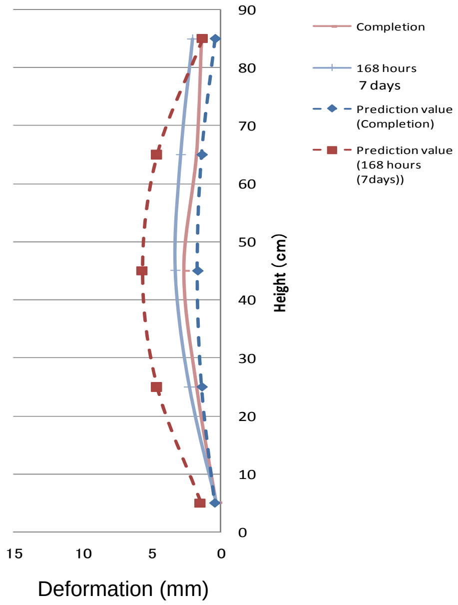


Figure 10. The comparison of experimental value and predictive value of creep deformation of reinforced soil wall used the non-woven netron Sheet

Figure 11. The comparison of experimental value and predictive value of creep deformation of reinforced soil wall used the polyethylene non-woven fabric.

It is shown that the deformation volume of ⊿Le and ⊿Ls is in inverse proportion to the size of the Young modulus. Therefore, it was attempted to apply the Young modulus shown in Figures 8 and 9 to these equations. The results are shown in Figures 10 and 11. The deformation when the reinforced soil wall completed, and the creep deformation after a week is shown in these figures, because the figure becomes complicated.

The solid lines are the experimental values, and the dotted lines are predictive values calculated in equation (3). As shown in these figures, the error is at most about 7mm. The predictive values agree approximately with the actual values in this experiment. From these results, it is considered that equation (3) can be utilized for the design method of a reinforced soil wall taking into consideration creep deformation.

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