Geotextile Reinforced Embankment of Clayey Soil with High Water Content

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ABSTRACT: In Japan clayey soil with high water content, such as volcanic ash clayey soil and excavated waste soil, is often used as banking materials. The best strategy in such a case is to dissipate the excess pore water pressure, using geotextiles as horizontal draining materials, and reinforcing the soil through consolidation. We were able to construct test embankment to investigate the suitability of geotextile reinforced embankment of clayey soil with high water content. Test results suggested that the laying of closely-spaced spunbonded nonwoven fabrics (we used 30cm intervals) is a highly suitable technique for reinforcing high embankments of clayey soil with high water content. This technique integrates the embankment as well as assisting consolidation of the embankment.

1 INTRODUCTION

In Japan clayey soil with high water content, such as volcanic ash clayey soil and excavated waste soil, is often used as banking materials. Chemical stabilization has traditionally been used in such cases to ensure trafficability for construction machinery and improve soil characteristics. We were able to construct test embankment to investigate the suitability of geotextile reinforced embankment of clayey soil with high water content.

Embankments constructed using clayey soil with high water content are often rendered unstable from the generation of excess pore water pressure during construction. The best strategy in such a case is to dissipate the excess pore water pressure, using geotextiles as horizontal draining materials, and reinforcing the soil through consolidation.

Geotextiles were chosen for their ability to increase tension as well as the consolidation effect due to drainage.

Observations of the test embankment provided data on the generation and dissipation of excess pore water pressure in the embankment, geotextile strain, deformation of embankment and the incidence of surface layer sliding.

2 TEST EMBANKMENT

A mixture of volcanic ash clayey soil and sandy silt from construction borrow pit was used as banking material. As shown in Photograph 1, the soil layer at the borrow pit consisted of brown sandy silt of 50% natural water content at the top, followed by dark gray volcanic ash clayey soil of 130% water content and whitish-gray volcanic ash clayey

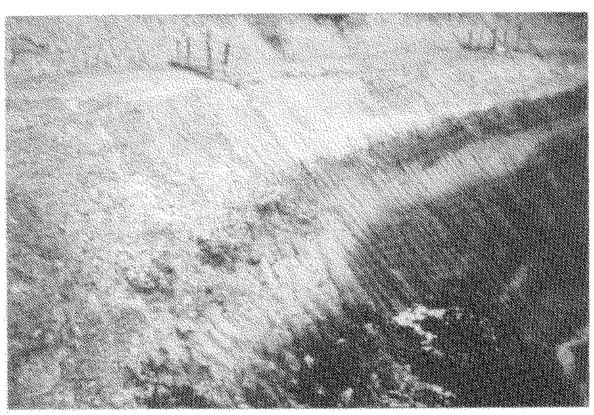


Photo. 1 Soil Layer Composition at Borrow Pit

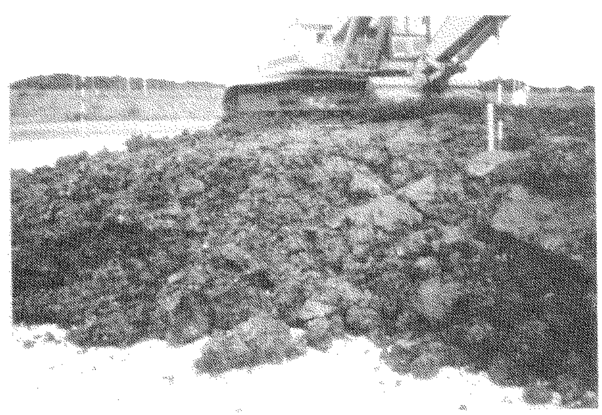


Photo. 2 Banking Material after Excavation and Removal

soil of 40% water content. The soils from each of these layers were mixed after excavation (see Photograph 2), with moisture contents being dispersed between 50% and 120% according to the mixing ratio.

The average water content of banking material measured during banking was about 70%, although this differed markedly between layers since water content is affected by weather. The degree of saturation of each layer after conpaction was generally between 90% and 99%.

Polymer grids and spunbonded nonwoven geotextiles were used for reinforcement.

Figure 1 shows the standard cross section and Figure 2 the plan of the test embankment. The embankment was 7m high, 15m in crest width and 25m in crest length, with a slope gradient of 1:1.5.

Two test cases were set up on either side of the centerline of the embankment. The first had 3mm thick spunbonded nonwoven geotextiles laid at 30cm intervals, while the other used polymer grids at 60cm and spunbonded nonwoven geotextiles at 120cm intervals. In both cases, the super elevation was 4%.

A weak 3-4m layer was distributed in the underground. No special efforts were made to reinforce this since it was relatively thin. A 50-130cm thick sand mat layer was laid

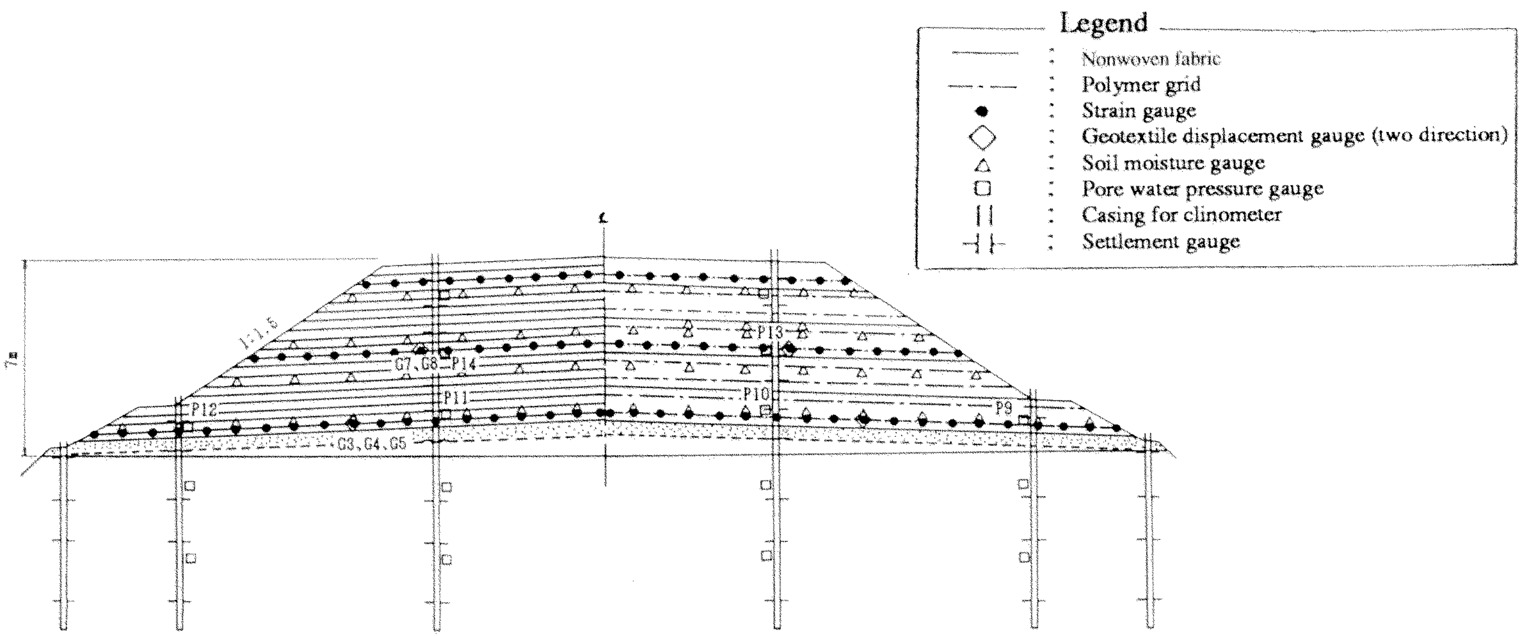


Fig. 1 Standard Cross Section of Test Embankment

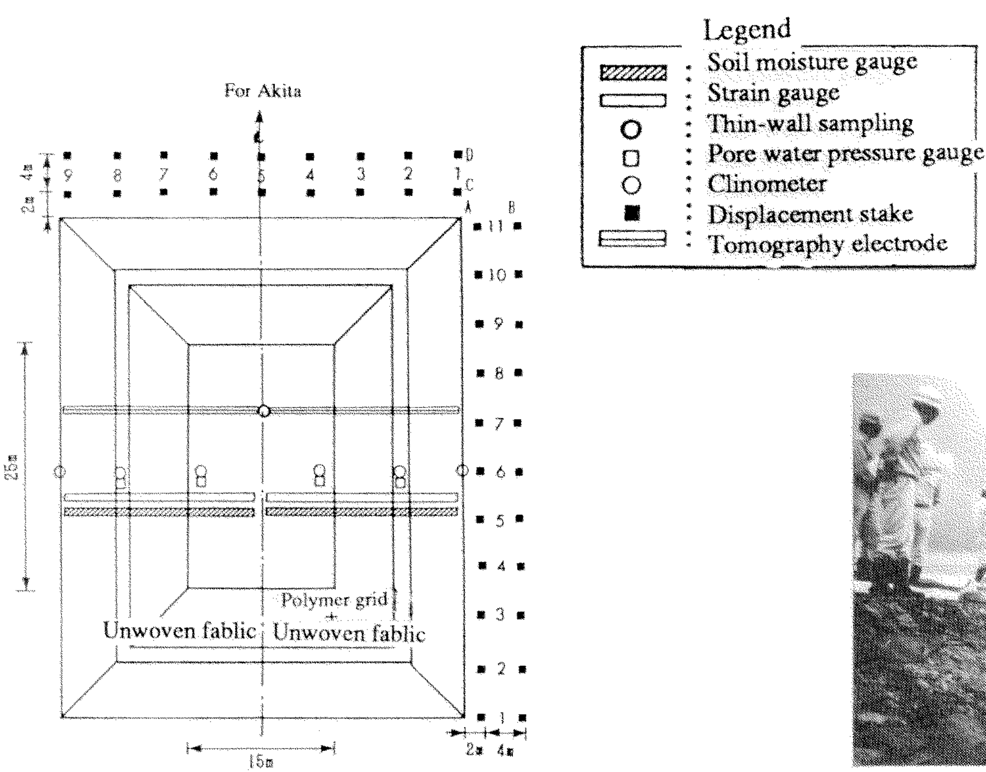


Fig. 2 Plan of Test Banking

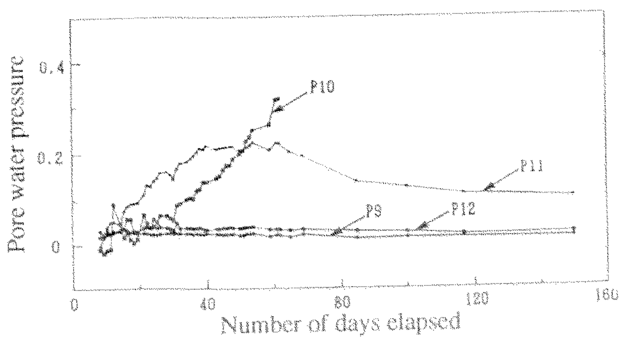
Photo. 3 Nonwoven Fabric Side of Slope

on the ground surface.

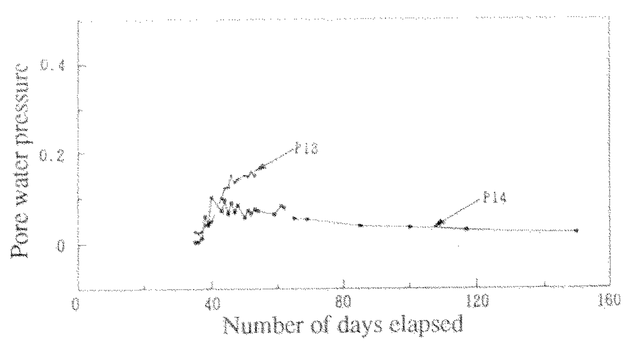
Observations were made on geotextile strain, pore water pressure in the embankment and the ground, and settlement and deformation of the embankment and the ground. Measurements were taken at the positions indicated in the drawings.

The spunbonded nonwoven fablic were 3mm thick, with tensile rupture strength of 3.8ft/m and rupture strain 70%. The polymer grids were of biaxial orientation, with a tensile rupture strength 1.9ft/m and rupture strain 11%.

Photo. 4 Banking Completed



(a) 2nd Layer



(b) 9th Layer

Fig. 3 Generation of Pore Water Pressure

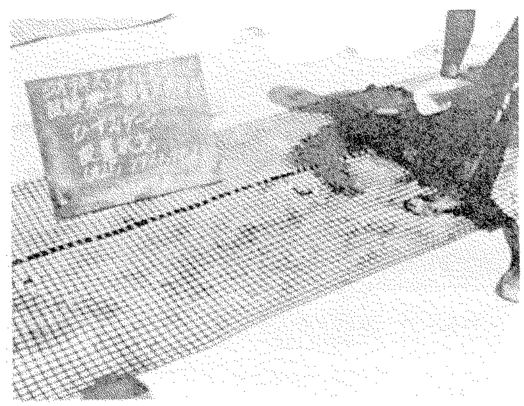
3 TEST RESULTS

Figure 3 shows data recorded by the pore water pressure gauges installed in the 2nd and 9th layers of the embankment. The excess pore water pressure rises in the inside of the embankment before being dissipated rapidly on the side with the spunbonded nonwoven geotextiles. It can also be seen that the rise in excess pore water pressure during construction is quite large on the polymer grid side, where the geotextiles are spaced widely. It can be concluded therefore that excess pore water pressure will be dissipated quickly if spunbonded nonwoven geotextiles are laid at close 30cm intervals.

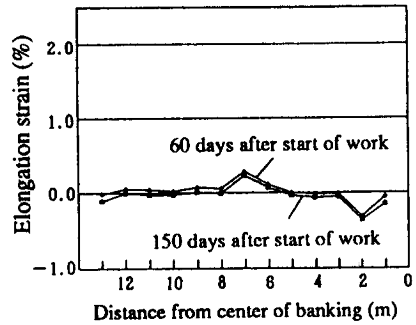
Figure 4 shows the strain generated in geotextiles in the 2nd and 10th layers of the embankment on the spunbonded nonwoven fablic side, and Figure 5 the same on the polymer grid side.

This indicates that on the polymer grid side of the embankment, strain of about 1% to 2% was generated in the polymer grid and considerable tensile forces acted on the polymer grid, while on the spunbonded nonwoven geotextile side, only an extremely small amount of strain was generated in the spunbonded nonwoven geotextile. The peak of the strain in the geotextile appeared about 2 months after the beginning of the execution, and the strain fell after this point. This suggests that consolidation increases strength of the soil and tends to stabilize the embankment. The strain in the spunbonded nonwoven geotextile shown in Figure 4 was, as shown in Photograph 5, measured using a plastic net, but a comparison of this with the records from the geotextile displacement gauges attached directly to the spunbonded nonwoven material allows us to conclude that, almost identical records were obtained, and that the spunbonded nonwoven geotextile strain data shown in Figure 4 is fully dependable.

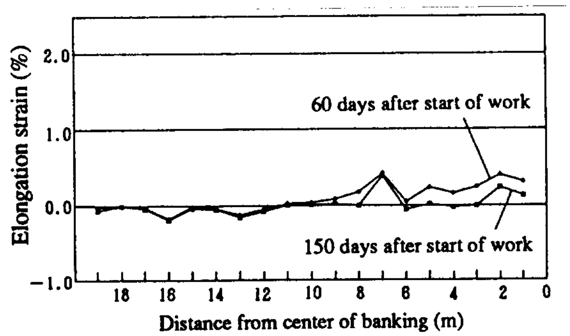
Overall judgments from factors such as the incidence of surface layer sliding, the generation of excessive pore water pressure in the embankment, and geotextile strain during and after the execution that has already been described,



Photograph 5 Plastic Net Used to Measure the Strain of the Spunbonded Nonwoven Material

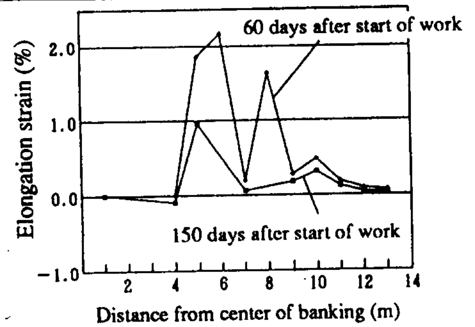


(a) 10th Layer

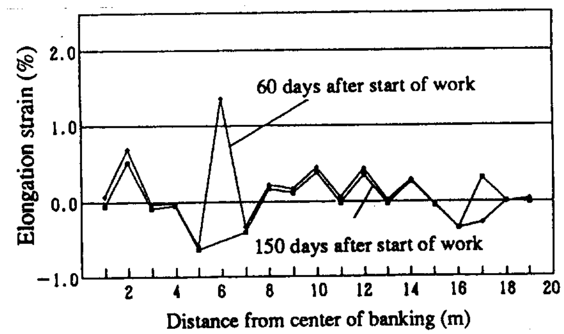


(b) 2nd Layer

Fig. 4 Generation of Strain in Spunbonded Nonwoven Fablic



(a) 10th Layer



(b) 2nd Layer

Fig. 5 Generation of Strain in Polymer Grid

indicate that when a high embankment is constructed using clayey soil with a high water content of the kind used in this case, laying closely-spaced spunbonded nonwoven geotextile which has low tensile strength but does provide a drainage effect can be counted on to promote considerable consolidation, which in turn integrates the embankment, shows that this approach is practical.

4. Conclusion

The effectiveness and practical usefulness of a construction method using geotextiles to reinforce high embankments made of clayey soil with high water content was tested and studied in a test execution section of part of an actual national highway that was under construction. Geotextiles were used to obtain the tensile reinforcement along with the consolidation promotion effects of spunbonded nonwoven material with drainage properties, and in this way, to guarantee the trafficability of the construction equipment and stabilize the embankment. Comprehensive judgments from the generation and dissipation of excessive pore water pressure, strain of the geotextiles, deformation of the embankment, and the incidence of surface layer sliding obtained from observations of the test embankment indicate that laying sufficiently closely-spaced spunbonded nonwoven geotextiles with drainage properties can be counted on to provide a greater degree of consolidation and to integrate the embankment. This conclusion proves that this an extremely useful method to employ with actual embankments made of clayey soil with high water content.